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GENERAL SCIENCE QUARTERLY

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General Science Quarterly

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Method in Science Teaching[1]

By John Dewey, Columbia University.

Method means a way to a result, a means to an end, a path to a goal. Method therefore varies with the end to be reached. Without a clear notion of the end, we cannot proceed intelligently upon the journey toward it. When we try to state the end of science teachings we are, however, likely to find ourselves involved in such vague generalities that all might use the same words and yet differ radically about actual method of procedure. It is therefore only to make clear my own point of approach and not to foreclose discussion that I say that the end of science teaching is to make us aware what constitutes the most effective use of mind, of intelligence. To give us a working sense of the real nature of knowledge, of sound knowledge as distinct from mere guess work, opinion, dogmatic belief or whatever. Obviously science is not only knowledge, but it is knowledge at its best, knowledge in its tested and surest form. Educationally then what differentiates its value from that of other knowledge is precisely this superior quality. Unless it is so taught that students acquire a realizing sense of what gives it its superiority, something is lost. If we ask how this superior type of knowledge came into existence we find that men have been working their minds, more or less effectively for many thousand years, and that for a very long time it was less rather than more effectively. But the most efficient ways of using or working intelligence have gradually been selected and cultivated. And science as a personal power and resource is an equipment of all those found most successful, most

[1] Address before the Science Section of the N. E. A., in New York, July, 1916.

effective. A man may have a good deal of cultivation, a good deal of information, correct information at that, about things, but if he has never made a first hand acquaintance at some point with scientific ways of dealing with a subject matter, he has no sure way of telling the difference between all wool knowledge and shoddy goods. He has no sure way of knowing when he is using his mental powers most capable and fruitfully. An ability to detect the genuine in our beliefs and ideas, the ability to control one's mind to its own best working is a very precious thing. Hence the rightful place of science in education is a fundamental one, and it is correspondingly important to see to it that methods of teaching are such as to fulfill its true purpose.

When we pass from this generality, it seems to me that the first need is to discriminate certain stages in the educational development of science. The first stage belongs of necessity to the elementary school, for I do not think that any amount of pains and ability in the high school can make up for a wrong start or even a failure to get the right start in the grades. This is contrary in appearance to a common assertion of secondary teachers that they would prefer that their pupils came to them without any science instruction at all—which is paralleled by a similar statement on the part of the college teachers. I think the inconsistency is only in appearance. The remark is really proof of the necessity of a right start. I do not believe that the problem of successful science will be met until teachers in college and high school exchange experience with those in the elementary school, and both take a mutual interest in one another's work.

At this stage, the purpose should be to give a first hand acquaintance with a fair area of natural facts of such a kind as to arouse interest in the discovery of causes, dynamic processes, operating forces. I would emphasize the clause regarding "of such a kind." I think the chief defect, upon the whole, in our present elementary nature study is that while it may arouse a certain interest in observation and accumulate a certain store of information, it is too static, and hence too miscellaneous. By static I mean that observation is directed in some active process. No amount of information of this sort can supply even a background for science. Space, however, forbids my dwelling upon this point, and its underlying point can perhaps be brought out by reference to something which lies within the high school program, namely,

so called general science. Like the nature study movement the tendency to general science courses is animated by a praiseworthy desire to get away from the specialized technicalities of a highly matured science. I will not say that these reduce themselves for the average beginning student to mere acquisition of a vocabulary, though there is danger of this. But except with the few this science of the accomplished specialist remains, even when fairly well understood, just an isolated thing, a thing of a world superadded to the everyday world, when it ought to be an enlightening and an intellectual control of the everyday world.

As an attempt to get back nearer to the world in which the pupil lives, and away from a world which exists only for the scientist, the general science tendency has, as I have just said, its justification. But I have an impression that in practice it may mean two quite different things. It may take its departure from sciences which are already differentiated, and simply pick out pieces from them, some from physics, some from chemistry, some from physiography, some from botany, etc., and out of this varied selection form something to serve as an introduction to sciences in a more specialized form. Now this method I believe to be of the static type after all. It gives scope for variety and adaptation, and will work with the right teacher. But urged as a general movement, I believe it retains the essential mistake of any method which begins with scientific knowledge in its already made form, while in addition it lends itself very easily to scrappy and superficial work, and even to a distaste for the continued and serious thinking necessary to a real mastery of science.

General science may, however, have another meaning. It may mean that a person who is himself an expert in scientific knowledge, forgets for the time being the conventional divisions of the sciences, and puts himself at the standpoint of pupil's experience of natural forces together with their ordinary useful applications. He does not however forget the scientific possibilities of these experiences, nor does he forget that there is an order of relative importance in scientific principles—that is to say, that some are more fundamental, some necessary in order to understand others, and thus more fruitful and ramifying.

While then he may take his subject-matter from any of the ordinary and more familiar materials of daily life, he does not allow that material in its obvious and superficial form to dictate

to him the nature of the subsequent study. It may be varnish or cleansers, or bleachers, or a gasoline engine. But he never for a moment allows in his educational planning that thing to become the end of study; when he does, we have simply the wrong kind of elementary nature study over again. To him, as a teacher, the material is simply a means, a tool, a road. It is a way of getting at some process of nature's activity which is widely exemplified in other phenomena and which when grasped will make them more significant and more intelligible. While the student's attention may remain, so far as his conscious interest is concerned, upon the phenomena directly in front of him, it is the teacher's business to see that he gets below the surface to the perception of whatever is scientifically in the experience. This need not be labelled a principle or law—in fact, if it it so labelled at first, the name principle or law will be merely a label. But if further material is selected so that what the pupil got hold of before serves as a means of intellectual approach and understanding, it becomes a principle or law for him: a law of his own thinking and inquiries, a standpoint from which he surveys facts and attempts to reduce them to order.

This same method of procedure means of course that choice is made in fixing the kind of familiar material with which one sets out. The interests and occupations of the environment will play a part. A farming environment would tend to provide one point of departure, a district in which electric apparatus was made another, a railway center a third, and so on. But in each case, there will always be room for choice between material which tends to begin and end in itself and that from which something may be easily extracted which will give pupils a momentum to other things.

My point may perhaps be stated by saying that the right course lies between two erroneous courses. One method is the scrappy one of picking up isolated materials just because they happen to be familiar objects within the pupil's experience, and of merely extending and deepening the range of the pupil's familiarity, and then passing on to something else. No amount of this will make an introduction to science, to say nothing of science, for an introduction leads or draws into a subject, while this method never, save by accident, gets the pupil within the range of problems and explanatory methods of science. The other erroneous course is taken when the teacher's imagination is so limited that he can-

not conceive of science existing except in the definitely segregated areas, concepts and terms which are found in books under the heads of physics, chemistry, etc., and who is thus restricted to moving within these boundaries. Such a person forgets that there is no material in existence which is physical or chemical or botanical, but that a certain ordinary subject-matter *becomes* physical or chemical or botanical when certain questions are raised, and when it is subjected to certain modes of inquiry. What is desired of the pupil is that starting from the ordinary unclassed material of experience he shall acquire command of the points of view, the ideas and methods, which *make* it physical or chemical or whatever.

I return to what I said at first about the dynamic point of view as the really scientific one, or the understanding of *process* as the heart of the scientific attitude. What are called physics and chemistry deal in effect with the lawful energies which bring about changes. To master their method means to be able to see any observed fact, no matter how seemingly fixed and stubborn, as a change, as a part of larger process or on going. In this sense, they are central (along with mathematics which alone deals with the fixed, the formal and structural side of the fact) in all scientific understanding. There is a sound instinct in the tendency to insist upon them as the heart of the secondary course in science and to look with jealously upon whatever narrows their sphere of influence. But it does not follow that the material which is found in the text which segregates certain considerations under the heads of physics or chemistry is the material to begin with. That is the fallacy against which I have been arguing. Plant and animal life, the operations of machines and the familiar appliances and processes of industrial life, are much more likely to furnish actual starting material. What the principle calls for is that the pupil shall be *led* in his study of plant and animal life, of machine and its operations, to the basic operations which enables him to *understand* what is before him—to be led inevitably to physical and chemical principles. Nothing is more unfortunate for education than the usual separation between the sciences of life and the physical sciences. Living phenomena are natural and interesting material from which to set out, especially in all rural environments. But they are educationally significant in the degree in which they are used to procure an insight into just those principles which are not plants and animals, but which, when they

are formulated by themselves, constitute physics and chemistry. It is the failure to carry nature study on to this insight which is responsible for its pedagogically unsatisfactory character: and the movement toward general science will repeat the same unless it keeps the goal of physical and chemical principle steadily in view.

An extension of the method I have spoken of should in my judgment constitute the bulk of the secondary course in science, which ideally should be continuous thruout the four years—or the six. We must remember that altho in school we are always treating pupils as embryonic scientists who somehow get interrupted and cut off before they get very far, the great mass of the pupils are never going to be scientific specialists. The value of science for them resides in the added meaning it gives to the usual occurences of their everyday surroundings and occupations. None the less, we want a high school which will tend to attract those who have a distinct calling for specialized inquiry, and one which prepares them to enter upon it. I can only express my belief that there are many more such in the pupil population than we succeed at present in selecting and carrying on, and that I believe this is largely because we follow to so great an extent the method of feeding them all from the start as if they were full fledged minute specialists. As a result large numbers who might otherwise be drawn later into the paths of scientific inquiry now get shunted off into the more concrete and appealing paths of engineering, industrial invention and application—simply because they have been repelled by a premature diet of abstract scientific propositions, lacking in meaning to them because abstracted from familiar facts of experience.

I believe there are scores if not hundreds of boys, for example, who now go from technical courses of physics into automobile factories and the like, who, if they had begun with the automobile under a teacher who realized its scientific possibilities, might have gone on into abstract physics.

I can sum up by saying that it seems to me that our present methods too largely put the cart before the horse; and that when we become aware of this mistake we are all too likely to cut the horse entirely loose from the cart, and let him browse around at random in the pastures without getting anywhere. What we need it to hitch the horse of concrete experience with daily occupation and surroundings to a cart loaded with specialized scientific know-

ledge. It is not the business of high school science to pack the cart full—that will come later. It is its business to make such a good job of the hitching that every pupil who comes under its influence will always find in himself a tendency to turn his crude experiences over into a more scientific form, and to translate the bare science he reads and hears back into the terms of his daily life. When we do this, we shall find, I am confident, the crop of scientific specialists increased, not diminished, while we shall have a citizenship of men and women really intelligent in judging the affairs of life.

The University and Business[1]

BY A. D. LITTLE, Boston.

It is a platitude to say before an audience like this that there is a great need at the present time on the part of bankers, capitalists, men of affairs, and directors of industry, and in no less degree on the part of superintendents, foremen, work people and the public generally, for a better appreciation of the part which science plays in furthering industrial development, increasing the efficiency of production, raising the scale of wages, and insuring preparedness, whether for peace or war.

BUSINESS MEN IGNORANT OF SCIENTIFIC POINT OF VIEW

This need arises from the fact that men of affairs, and especially financiers, have seldom received a scientific training or acquired a working knowledge of the scientific method or fully understood the scientific point of view. They consequently often fail to realize the intrinsic merit of industrial propositions which are based essentially upon new application of applied science, and to gauge with accuracy their chances of success.

PREVALENT IGNORANCE OF ORDINARY SCIENTIFIC PHENOMENA

Those of us who have received the benefit of any sort of scientific training are constantly amazed at the ignorance of cultivated men and women, business men and work people, regarding the simplest phenomena by which they are surrounded. To a deplorably large proportion of the community the striking of a match, the lighting of a fire, the freezing of water, the falling of snow, the sending of

[1] Extract from address before the New York Section of the Society of Chemical Industry, December 10, 1915.

a telegram or a talk by telephone, the operation of a steam engine, or the turning on of an electric light involves mysteries as far beyond their range of thought as the cause of gravitation or the rotation of the nebulae.

Since business involves at every point contact with natural phenomena and since the proper understanding of these phenomena or at least some realization of what underlies them, often determines the measure of success attained in business, the university might well establish a compulsory elementary course in *general science*. This should be designed to give the student at least a rudimentary knowledge of the field covered by the different sciences, the relation of the field covered by the different sciences, the relation of their subject matter to natural phenomena in the affairs of every-day life and those of business, the interdependence of the sciences, and, above all, a clear idea of the scientific method. Such a course could not fail to prove an immense stimulus to any intelligent mind. It would open out new horizons for thought and put an altogether different and more interesting aspect on the world in which we live and in which we must do business.

Connecticut System of Elementary School Science

By Lothrop D. Higgins, Head of Science Department,
State Normal School, Danbury, Connecticut.

Fifty-seven science cabinets were bought by towns in Connecticut during the past year for use in the elementary schools. Twenty-five more were in use, having been loaned by the State Board of Education. These cabinets contain material for demonstration exercises in physical science, with a booklet of information and suggestions for experiments and lesson procedure; they are followed by a series of occasional letters intended to direct and encourage the teachers who are doing the work. The state has made and loaned these boxes of apparatus for some years, but the increasing demand made it seem wise to attempt their sale. In a few cases the town bought more than one cabinet, but the whole number of towns in the state that are using them is over fifty. The fact of these boxes having been bought by the town after

previous opportunity to use them free of expense would seem to indicate that somebody thought the work worth doing.

This is the present status of a several years' effort to establish some teaching of everyday science in the elementary schools. The purpose is not to have some recognized branches of science taught in the lower schools, but rather to try and overcome certain defects in the results of common school training. The great majority of people take very little interest in any of the wonders about us that do not immediately concern them, and have little capacity for independent thinking when new situations require it. And this in an age which is more than ever being enriched with what man has drawn from his surroundings by his own study and invention. The primary object of this work in natural science is to give pupils an intelligent curiosity about the useful and interesting things around them, and make them do more real thinking.

The first, and we might almost say the one, great need is for teachers who can do it. The teacher who has the spirit and the ability to do this work can do it anyway—whether or not she has any "apparatus" or can get the time set apart on her program. Many a good teacher, at odd times and in the course of other subjects, has given some of her pupils the great inspiration of their lives. But teachers are shy at starting this work, even though they know its results to be felt in the general good of the school, because they feel their lack of knowledge. It is hard to meet the questions of earnest pupils, and it is hard to realize that she who is herself a student of the same things with them makes the best teacher. Almost any good elementary teacher has knowledge enough to serve as a foundation for this work, if she only knew how to go about it and had confidence. The confidence and the realization of its worth will come as she gains experience, as will also the better technique and the increase of information. But it is necessary at the beginning to help each teacher along all these lines as much as possible without making her dependent on that help. Hence the cabinet of apparatus, the booklet of information and suggested procedure, and the occasional letters that follow.

The work as laid down in the booklet is based upon physics, mostly such matters as would fall under physical forces, effects upon liquids and gases and heat. Ninety-six experiments are described, and their relation to the lessons is indicated by questions, to which answers are given also. Principles and numerous applications are given. The cabinet contains the material necessary for

all the experiments. The box complete with the booklet is sent by mail to any school in Connecticut for $7.50; this is as near the exact cost as can be figured, excluding the labor of making some of the pieces and assembling the material. Provision is made for replacing lost or broken pieces at cost. The whole matter of making and caring for the boxes and apparatus is handled at the Danbury Normal School, with the financial help of the State Board of Education.

The experiments are simple demonstrations of familiar phenomena, each of which serves as a basis for discussion of kindred things which the pupils have noticed, with a view to finding the general truth that is common to them all. Then the pupils are encouraged to look for other cases where this same truth applies, and further lessons are based on the results of such inquiry. This in brief is the general method, though occasional lessons are conducted on other lines. It is by no means important that the work should be based on physics. It was necessary to place some information, material and definite directions at the teachers' command, and this could be done more economically with these than with any other subjects of equal breadth and value. But the teachers are encouraged to digress from this prescribed outline and use other material whenever they feel they can do it profitably. The great thing is to get both teacher and pupils working together in the spirit of real students, and when this spirit prevails the question of what subjects are used may well be settled by circumstances.

But it takes time and frequent repetition to implant ideas as working principles in others. The teachers are given some aids whereby they can do certain definite work, and this should help to start them. But the matter cannot be taken up in rural teachers' meetings often enough to be effective, and supervisors have many other matters that demand attention. So we are trying the plan of following up each teacher with a series of "letters", about a month apart, in which the methods and purposes of the work are discussed. These letters go to each teacher who has a cabinet, and to her supervisor. They are planned with a view to first helping the teacher with her immediate problem, and finally working around to where the significance of the work will be apparent—by which time it is hoped also that she will want to go ahead with subjects of her own choice, in which she has become interested. The letters are printed and there is no charge for them.

Most of these boxes have gone to the smaller towns, where the work is done chiefly in one-room rural schools. A few have gone to city schools, and some other Connecticut cities are doing similar work in science. In Stamford it is done in the upper grades as departmental work by a teacher who is capable and willing. In Norwalk it is carried on by room teachers under close supervision of the high school science department. In New Haven and Danbury it is in charge of the normal schools.

In the one-room rural schools the work is usually done with all classes from about the fourth stage up, reciting together. In the city schools it is done chiefly in the seventh and eighth grades, though there is no reason why it cannot be profitably used in lower grades, as it sometimes is. Two twenty-minute periods a week are usually allowed, though in the two upper grades the periods are sometimes longer. The work indicated in the booklet could be extended over two years by some teachers, while others might go through it in one; in Danbury it covers three half-years, with kindred work from other subjects in alternate half-years.

But this is pioneer effort at a thing which holds far more worth than these attempts alone are going to bring out. It is a shame and a real loss to our civilization that as a people we know and care so little about the interesting and important knowledge that is so close at hand. These efforts may fail and the subject die out from our schools, but the time will come when thought-and-interest lessons based on natural science will have their established place in the common schools of America.

Project Teaching[1]

PROF. C. R. MANN, of the Carnegie Foundation.

There seems to be a general impression that project teaching and general science courses are suitable only for grammar schools and the early years of the high school. Even the high school teachers themselves speak of the need of a regular or formally organized science course for the third and fourth years. So far as I am aware, no one has yet proposed general science courses for the colleges and universities. Yet the work of all the research men in

[1] Abstract of address delivered at a General Science Conference at Salem, Mass.

the country and the work of the advanced students in science is always carried on by the project method and is successful in proportion as the project is really the student's own.

The same is true in the engineering colleges. Among the professional engineers there is a very marked demand for what they call "general engineering science". It is pointed out that a man who graduates from a civil engineering course frequently makes his success in life in mechanical engineering or vice versa. It is also pointed out that all engineering problems are essentially projects and that many of them involve a very wide knowledge of the different fields of science. To be a successful engineer thus involves having the ability to tackle and solve projects efficiently and this ability is acquired like every other ability by practice and training in doing. It therefore follows that the most efficient training of engineers is likely to be secured in those schools in which the project method of instruction is used most freely.

It is difficult for teachers to get started with the project method because it is so different from the one by which we were ourselves taught. Professor Dewey has given us a formula which is very valuable if it is used intelligently and not followed too blindly. This formula may be stated in this way: The old system of instruction had for its aim, first the development of technique on the ground that this technique might at some future time be of use to the student. The project method teaches technique only in response to the personal need felt by the student himself. The formulae thus will run:

Old Method: 1-Technique 2——?
New Method: 1-Need 2-Technique.

Projects

By J. C. Moore, High School, Bridgeport, Connecticut.

Much of the science teaching of the past reminds me of a remark made by a young Chinese student of my acquaintance. After seeing one of his first games of American baseball, in which his school team was badly beaten, due to a number of wild throws, he was called upon to give his version of the defeat. "Well", he said smiling, "our team have only one fault, they throw the ball where there isn't anybody." Much of our science teaching is thrown where there isn't anybody. In other words, it doesn't reach its

goal, largely because the subject matter and the method are not vitally connected with the needs and interests of individual students.

In teaching science by projects we try to start with the live curiosity of the boy or girl as based in the solution of their needs. Professor Dewey in his book, 'How We Think', has given us the key for good teaching, and his outline of the process furnishes the method for handling future projects.

No teacher can tell just how a given project may arise, in just what form of question the need may be expressed, but the need will usually express itself spontaneously. The same project may arise in a dozen different forms, but when once expressed, leads into many different fields where the boundary fences of subject matter have long since ceased to exist. Today a girl may seek, "Why rain water makes better suds than tap water?" or "Why a crust forms inside the teakettle?", a boy may ask, "Why do boilers explode?", or "Why is Great Salt Lake so salt?" In each event the project of Hard Water is started, and will lead us through the various connecting links, gathering much desired information on the way, until we feel the satisfaction of solution. It will touch several subjects, it may take one or several periods, it will be vital, if not, it ceases to be a project for us.

The student usually sees only the first term of the process, need—technique—future needs, though he is constantly working toward the last term. Only through solving present needs can future needs be met, and the skillful teacher will study the last, as the student studies the first term. Through careful guidance of the project, by suggested lists of readings, by proposed experiments, by his own enthusiasm, the teacher can do much to strengthen the project method of attack.

The story of the student in manual training class, who enthusiastically entered upon the work of preparing garden-pegs for the spring planting, only to feel disgust at being kept for days at squaring, planing and sandpapering the part underground, illustrates the feelings of many present day students. Work done because it is vitally interesting to the individual and meets his needs, is of more permanent value than work done merely to meet the pleasure of a teacher.

Our work will be greatly aided by having the possibilities of a project well in hand, not that it may all be covered by each suc-

ceeding class, but as a kind of guide board leading to enchanted lands of investigation. Such a series of projects as the one here given in brief, can be listed on library cards with reading references listed on the back, and will grow in value with succeeding years.

Hard Water

Scum when soap dissolves in water?—Bathtub.
Soap dissolves better in rain water than spring water.
  Used to catch it in country.
  Too much dirt and gas in city. CO_2, SO_2.
Rain water may be acid.
  Even destroy architectural detail—Pittsburgh.
  Cost to city—Rust—Cleaning buildings and windows.
Ground water.
  Decaying vegetable acids.
  Carbonic acid—Saratoga.
  Dissolves rocks—limestone—Na, Ca, Mg, CO_3, SO_4, Cl.
Demonstration. $CaCO_3$ by carbon dioxide in lime water.
  dissolve by excess of carbon dioxide.
Limestone caves. Kentucky—Mammoth Cave.
  Stalactites, stalagmites from saturated solution.
Natural bridges.
Mineral springs, geyser deposits, Yellowstone Park.
  Travertine of Italy.
Soil leaching—Mississippi deposits.
Sea water—Dead Sea—Great Salt Lake.
Minerals reappear in teakettle—$CaCO_3$.
  Boiler scale—cause of explosion.
Temporary hard water—calcium acid carbonate.
  Effect of boiling.
  Permanent hard water.
  Calcium sulphate, less soluble in hot water.
  Softened by soda.
How soap reacts with hard water.
  Calcium soap.
  Soap softens hard water.
Cost of softening by soda.

Relation of General Science to Later Courses in Physics and Chemistry[1]

By Lewis Elhuff, A. M., George Westinghouse High School, Pittsburgh, Pa.

This subject might suggest that I am attempting to assume the role of a prophet who is able to determine the nature of Physics and Chemistry as they will be taught in the future. But since the topic was assigned to me rather than of my own choice, there is some evidence that there are others who are conscious of the prophetic phase in all teaching, for teaching is training both for the present and the future. The one who understands the present well, will be very apt to choose wisely for the future. Then so far as we are teachers, we are also prophets. This places us all in the same class and I am no different from you in that respect.

Approaching this subject from the standpoint of the teacher, I would like to divide all teachers into two groups. These two groups are suggested by the attitude which teachers take with respect to what is commonly known as "General Science".

The first group consists of those teachers who teach a subject or develop a subject from the standpoint of the subject itself and make the student conform to the subject matter which the teacher thinks makes an ideal course because of the worth and beauty of the subject matter itself rather than the usefulness of the subject matter to the student pursuing it. This group of teachers want students to be purposefully prepared for the courses which they teach. (Under our present system of class grouping of students, it is a great advantage to have the students grouped according to the previous training. An advantage to whom? The teacher? No. It is an advantage to the learners, because under proper classification they will get more training during a given amount of time.)

The Physics and Chemistry teachers of this first group expect their students to have been trained or drilled in some of the fundamentals of these subjects and even to know how to perform experiments and write up notes in the form in which this group of teachers want them. Just as though learning to do experiments and writing laboratory note books were a business in itself. So much

[1] Address before the Chemistry Section of the N. E. A., at New York, 1916.

of our laboratory work, is so formal that students are hindered rather than aided by it in securing useful knowledge and training. For a laboratory exercise, a proposition should be set and then let the student use his own originality and inventiveness to attain the desired end. The teacher by observation discovering the students difficulties, may lead him forward by suggestions or suggestive questions if it seems necessary for the progress of the student. Here I would like to suggest that the grandest laboratory of any High School, is the community in which that High School is located. To use this laboratory requires a different method than that used in most laboratories and a different attitude on the part of the teacher towards his subjects and his learners.

This bring us to the second group of teachers, namely, those who teach from the standpoint of the student and make the subject fit the student so that it will give him useful training for the present and future. This attitude requires the teacher to center the attention on the learner and study his characteristics and previous training and then adapt the subject matter to suit the circumstances which the teacher has discovered. (Here again I would like to suggest that learners who are grouped according to their previous training, will receive more training in a given amount of time than if they are not so grouped.)

This attitude on the part of a teacher requires the teacher not only to know the subjects being taught, but to know it so well that the subject can be adapted to the conditions in which the learner is found. The learner should be first in the mind of the teacher and the subject matter second. Keep in mind that living human beings are to be taught and not science subjects. Is this idea new? No. The great teachers, both religious and secular, who stand out in educational history had this conception of the relation of the subject matter to the learner.

On this basis or from this attitude I can make only one complaint or offer but one compliment to the teachers who send their students to me, namely, the students are not well trained or they are well trained considering the time the students spent with their teachers and the circumstances under which those teachers and students were working. This attitude also requires me to look upon a student as having received all the training that he can get from his former teachers who sent the student and who like most teachers are limited in their field of activity by an authority higher up.

On this basis to fail a student is to reclassify him for his benefit.

You have perhaps already discovered my attitude towards the relation of General Science to later courses in Physics and Chemistry. It is this—General Science has no more relation to future courses in Physics and Chemistry than it has to future courses in Botany, Zoology, Physiology, Physical Geography, Horticulture, or Bacteriology. General Science has a very vital relation to the present and the future of the student pursuing an acquaintance with himself and his environment the same as Physics, Chemistry, Zoology, etc. have a vital relation to the present and future of the student.

From this point of view I would like to go more into detail on this subject. What should be taught in a General Science course given during freshman year in High School considering the age and training of the student coming into our High Schools? The answer is, teach the student what he needs, what he can use. To do this the teacher must be a student of Sociology as well as Psychology and Pedagogy, and must study the social environment of the students in order to learn as much as possible about the students' experiences and the extent and nature of their observations and previous school training.

The previous school training that students have received will largely determine the method which can be used at the beginning of a General Science Course or any other course. A change in method means a change in formed habits of doing things. When students have formed the habit of parroting definitions of technical terms or quoting the text book or teacher, it is a difficult and slow process to get them to talk freely of their experiences which they have received outside of the text books or class room. Here it might be suggested that students who are taught to parrot definitions of technical terms used in Physics and Chemistry would be looked upon by some teachers as being well prepared to study Physics and Chemistry.

Of all the things which the General Science student should be introduced to, I would like to suggest the following.—1st. The students own health. 2nd. The health of the family from which the student comes. 3rd. The health of the community in which the school is located; all from the hygienic standpoint. The health of the family and community are reached thru the health of the student.

Some of the things which relate to health and are common to all communities are—habits of the students in school, on the street, and in the home; the home, its heating, lighting, ventilation, and surroundings including plants and animals; sanitation in the home, cleanliness, nature and kinds of food consumed, apparatus and chemicals of the home; water supply and its purity and adaptation to the weather. These to be studied in detail to the extent of their usefulness to the students concerned.

These topics will not have the same characteristics in the environment of all schools and so it will be very necessary for the teachers to study local conditions in order that their teaching might be of service to the student body and community. These things are to be taught for the sole purpose of their usefulness to the students immediate needs and not to prepare a student for some future subject. The student who is prepared to live as completely as possible, will also be prepared to study any subject that is adapted to his age and degree of training.

How teach General Science to prepare students for Physics and Chemistry or any other subject? The answer is—Teach them in the same way as you would if they never intended to take up a more advanced subject, in other words, teach them how to live. That cannot be done by cramming and by parroting, but by drawing out and developing what capacities they have, that is, lead the student to discover himself or herself.

The general principle of all teaching is to proceed from the known to the related unknown. Every student has a quantity of experience which is sufficiently understood by him to be used as a foundation and also as a basis for helping the student to interpret new experiences and new facts. Every student also has a quantity of experience of which he understands a part. The part which he does not understand must be interpreted in the light of his experiences which are already clear and useful. The number of definite and distinct ideas in the students mind should be increased, the imagination developed, and the vocabulary of the student should be increased as fast as possible, without parroting. Excessive technical terms whose definitions are committed by rote, are a hinderance to progress. Terms which the student uses in his discussions are the only ones which are really understood.

The laboratory work for freshmen should be largely outside of the school room. It should be in the home to a maximum extent

for two reasons. 1st. The learners will see a practical value in the experiment and the experiment itself will be practice. 2nd. It draws the parents into educational relations with their children and the school. The habits of whole families can be changed by this method, thus producing a better environment in the home of the student. This will go a great way in preparing a student for future courses in Physics and Chemistry or any other subject.

No laboratory experiment should be conducted in the school unless an immediate application of the experience gained, is made to life outside of the school. Students, even seniors, easily fall into habits of thinking that experiments have an end in themselves and they fail to see the use of the principles involved except to perform experiments.

Students can easily consume all their time in learning the things for which they have immediate use. Virtually they learn only those things which they use. When a graduate starting in practical work, says that he had to learn it all over again, he means that he did not learn it while taking his course in school. By a constant effort to teach only that which students can use immediately and by teaching it thoroughly enough so that they can use it, there are some mental processes involved that are very important, namely, the power of selection, comparison, reason, and judgment. These powers being highly developed, the student will be able to take care of himself and acquire the necessary information when the occasion in his practical life requires it. Information about a thing may be important but practical information which enables the student to apply and use it, is more important.

There are a great many subjects taught in our schools in such a way that the general public can see no use for them except for those who are going to be teachers. Not that the subjects have no value but the form of the material as presented and the method of presentation prevents adaptation to the students life unless the student makes practical application in spite of the methods and form of material; but such students are rare.

I would here like to suggest that you do not interpret what I call practical, in a narrow sense. Much of what some call cultural has a practical value in so far as it enables the student to understand his social and natural environment. Music, Art, and the related subjects which develop emotions and the aesthetic sense have a practical value in the daily life of the individual.

What I would like to impress upon you today is, to retain in General Science courses only the subject matter which can be adapted to the life of the student and let the same be done in Physics and Chemistry. Later courses in Physics and Chemistry will then contain only that which is of practical use to the student at the same time the courses are pursued. Later teachers of Physics and Chemistry will also have to see that their subjects are for the students use and not the students for the subject. The first year of Physics or Chemistry in High School can be confined to the Physics and Chemistry of the daily experiences of the student. This will mean the elimination of much that is now superficially taught in some schools and the addition of material with which the student is already partially familiar.

If later courses in Physics and Chemistry become what I have suggested, then how will General Science be related to them? The answer is at once apparent, namely, that General Science, when properly taught by adaptation to the life of the student, will have developed the student so that he will be able to think, judge, and apply information to new circumstances or conditions and have developed the habit of securing new information as is needed to meet a new condition. This quality in a student can be used in a home, on the street, in studies pursued in the future and in remunerative labor. A student possessing these properties will never fail to be benefited by a course in Physics and Chemistry if they are adapted to his capacity and immediate needs.

What then should be the aim of the teacher of General Science? Only this—adapt the subject matter to the student and teach him in such a way that he will be prepared to live now, and have no other thought of preparing him for any subject that is to follow except, the subject; "to live, to live completely, and to live abundantly." Let this also be the aim of Physics and Chemistry teachers, and there will be unity, continuity and co-operation.

Lightning

By W. G. Whitman, State Normal School, Salem, Massachusetts.

Lightning, that awe inspiring natural phenomenon which compels the attention of child and adult alike, is the cause of about 800 deaths and of 1500 injuries sustained by the people of the United States in a single year. It also causes the destruction of many millions of dollars worth of property yearly.

Lightning is a subject worthy of study in general science classes both because it commands intense interest and because a wider knowledge of its behavior and the practice of known methods of protection against it, would prevent much of the loss of life and property. Lightning is a more vital subject in the country and small village than in the city. It is rare that lightning strikes in the large towns or cities. The isolated building or object is in greatest danger. The subject is of varying economic importance too in different states. Records show that lightning does more damage in Iowa than in any other state. Maryland, Wisconsin, New York, Ohio and Illinois follow in the amount of damage received from this source.

That the harmless spark obtained by rubbing a cat's fur in cold winter and the terrifying lightning of a hot summer day are closely related, belonging as they do in the same family of natural phenomena, has never been surmised by the average pupil. In fact many older people have not thought of them as related phenomena, even though Franklin proved their identity in 1752.

Benjamin Franklin while experimenting with electricity noticed certain resemblances between the sparks produced artificially and the natural lightning. Both flashes were instantaneous; gave intense light; followed a crooked path; produced noise; set combustible material on fire and killed animals. From observation of the similar behavior of the two, he was lead to a strong belief in their identity so he determined to perform some experiment which would prove their likeness or unlikeness. And on July 4, 1752 he sent a kite into the clouds during a thunder storm and succeeded in bringing electrical energy from the cloud through the kite string to a key at its lower end. This string and key were insulated from the earth by a silk cord. Franklin obtained sparks from the key just like those he had produced in his laboratory, thus did he

demonstrate to the world the fact that lightning is an electrical discharge.

The boy who shuffles his feet over the carpet and draws a spark from the water faucet or gas burner is a "dynamo" unawares; he generates electricity and discharges it at a pressure of thousands of volts. There is sufficient experience in the average child's life anywhere above the fifth grade to insure keen natural interest in a study of an electrical storm. When you attempt to catalog that experience and to record what that experience is, you may not be able to get a very large list of observed facts, but with time for reflection and the stimulus of suggestion, enough can be obtained to make a good experience background.

Some of the facts which may thus be gathered from a class are the following: Lightning is a characteristic accompaniment of a certain type of storm. This is called a thunder storm or an electrical storm. These storms are common after excessively hot days in summer but occasionly occur in winter. The storm is ushered in by the beautiful white cumulus clouds and strong wind, then follow dark clouds, rain, electrical flashes and thunder. The rain drops which fall during an electrical storm are very large; as a rule much larger than fall during an ordinary rain. People and animals are killed by lightning; trees and poles are broken and split; houses and barns are set on fire; even the ground is sometimes struck by lightning. When people are burned by lightning their skin is said to record photographic representations of nearby objects. Different "kinds" of lightning are recognized. During an electrical storm, the trolley car may be stopped and will not move until the intensity of the storm has passed. Lightning arresters are used to protect the telephone and lightning rods to protect buildings.

It is usually true that the air above the earth is positively electrified and that the earth differs in electrical pressure from all space around it by many—possibly 150,000—volts. It is not constant however, conditions are always changing and the electrical tension is variable. Such a difference of potential as this is not sufficient to produce lightning.

When clouds are rapidly formed by air currents rising into the air, enormous quantities of electricity are produced. We do not know exactly how it is produced. The latest theory, that of Dr. Simpson, explains the electrification as resulting from the splitting

of rain drops into smaller particles as they tend to fall through a rapidly rising current of air.[1] In some way clouds do become highly charged with electricity. Sometimes they are positively charged and sometimes negatively charged. When two clouds or a cloud and the earth are at sufficiently great difference of potential the resistance of the intervening air is overcome and a discharge takes place producing the common phenomenon of lightning. Sir Oliver Lodge calculated that a flash of lightning one mile long is probably due to a difference of potential of 5,000,000,000 volts, but it is generally thought now that this figure is too high. Trowbridge has found that a difference of potential of about 25,000 volts between battery terminals will give a one-inch spark through air.

The duration of a flash of lightning is usually under 1-50,000 second and may be only 1-1,000,000 second. Because of persistence of vision we apparently see the flash for a longer time. According to calculations made by Lodge, a discharge from a cloud 10 yards square, fully charged, at a height of one mile, liberates 2,000 foot-tons of energy. This energy is enough to warm 40 grams of water to the boiling point and then change it to steam in a trifling part of a second. Such intense heat warms the particles of air to incandescence and is the cause of the flash seen. Heated air conducts electricity better than cold air, so at times other flashes will follow in the path of the first one before the air has become cold. These multiple or oscillating flashes may continue for 1-1,000 to 1-200 second but altogether they apparently make but one flash to the eye.

The discharge of this cloud, 10 yards square, gives enough energy, in 1-20,000 of a second, if properly directed, to hurl 1,000 barrels of flour 20 feet into the air. When this energy heats the air in the path of the lightning discharge it causes sudden expansion with explosive violence and when the expanded air cools and contracts a vacuum is formed, into which air rushes again with implosive force. When you blow up a rubber balloon to an excessive pressure, explosion results with a loud sound. When an incandescent bulb is broken, air rushes into the space and when it meets, it produces a loud sound from the implosion. These two cases illustrate the production of thunder. One part of a lightning flash may be a mile farther away from you than the nearer

[1] See page 11, Farmers' Bulletin, No. 367.

part. The thunder from the more distant part will reach you about 5 seconds later than that from the nearer part. Thus while a flash may be instantaneous, the thunder which you hear may be of considerable duration. Thunder from several flashes unite. Thunder may be reflected by one or more clouds. In these ways the rumblings, characteristic of thunder, are produced.

Objects standing on the surface of the earth become a part of it and are electrically charged the same as the earth. Standing above the earth's surface they form excellent discharge points since the air gap from them to the cloud is less than from the surrounding earth to the clouds, and furthermore, the electrical density or tension is greater at points, corners and angles than on surfaces. Whatever the object may be through which the discharge starts, it instantly becomes the conductor through which electricity passes either to or from a large area surrounding it. If an object only discharged an amount of electricity equal to that which it held before the discharge, there would be little danger or violence, but when it becomes the conductor to carry the electricity of a considerable portion of the earth about it, the large quantity of electricity passing in so brief an interval causes violence and damage.

A similar discharge of the earth occurs when an object on the earth is electrified by a near-by cloud by induction and a discharge passes between them. The discharges at the storm front are usually the most severe. After the first few discharges the air seems to become a better conductor and the lightning is less severe.

Any high object reaching above the earth carries the electrostatic field nearer to that of the cloud, thus increasing the possibility of an electrical discharge between them. The tremendous heat energy which is produced from the electrical discharge of a large cloud highly charged is sufficient to heat air particles to incandescence, to melt minerals and metals, to vaporize solids and liquids with explosive violence and to set fire to combustible matter. It is little wonder that trees are splintered and buildings set on fire when they make a path for the lightning to the earth—or from the earth—for it is believed that fully as many discharges are from the earth to the clouds as from the clouds to the earth.

Protection against lightning is needed on isolated buildings, tall chimneys, steeples, and flag poles. Protection is secured by use of a metal cage or series of rods with high points and the whole thor-

oughly grounded. The material must be of sufficient capacity to carry off large quantities of electricity and it must not corrode readily. Copper and galvanized iron are the two metals most commonly used for lightning rods. The lightning rods or conductors should not be insulated from the building because the object of the rods is to "drain" electricity from all objects about or apart of the building. Conductors ought not to be placed near or parallel to an inside pipe, because the discharge might jump through the wall to it, causing fire, or it might produce a powerful heating effect in it, resulting from induction. A safeguard against such a disaster is to connect the lightning rod system at the highest and at the lowest points with inside structural beams and water pipes. Sometimes gas pipes are connected but because of the inflamability of gas, many prefer not to connect them. All exterior metal work of the building, as gutters, railings, etc, either should be connected to the lightning rod at a level below their own or they should be grounded by a separate cable. The grounding of lightning rods is a very important matter. They are frequently connected to large copper plates which are buried in a mass of coke at a depth which is below the permanent water level of the earth.

The metal cage or rods should have a number of high points extending above the level of the building; and should have few joints and no sharp bends. Our commercial currents will follow good conductors around any amount of curving, but lightning will often jump off from a good conductor at a sharp bend, even though it must pass through a poorer conductor. Specifications for installing lightning rods and sizes of rods are furnished by the National Board of Fire Underwriters.

There are two ways in which lightning rods protects a house. First, they serve as conductors carrying the discharge harmlessly; second, they tend to discharge the earth slowly. Often such an amount of electricity escapes by this slow discharge that a lightning stroke is prevented or if not prevented, it is less severe. Occasionally a rodded house is struck, but the damage is much less than if the house had been unrodded. The idea that lightning rods draw lightning, and are a source of danger is unfounded even if the rods are poorly grounded. The majority of fires resulting when lightning strikes rodded buildings, occur when masses of metal, gutters, pipes, etc. are not connected to the lightning rods or are not grounded.

Lodge classifies lightning as *A flashes* and *B flashes.* The A flashes are less sudden and violent, and are what the Germans term "cold lightning." Lightning rods are effective protection against them. The B flashes are sudden and violent, and are what the Germans term "burning lightning." Lightning rods will not always safeguard against these flashes. Both the A and B flashes are fatal to man. *Ball lightning* is produced when the B flashes strike the ground. The A flashes are the more common. When a storm is at such a distance that flashes of light are seen but no thunder is heard, the flashes are termed *heat lightning.* The thunder may be refracted above the heads of the observer or it may be at such a distance that its intensity is so decreased as to become inaudible.

If a person forms a part of the conducting path of the discharge, he is likely to suffer and yet the stroke may not prove fatal.

The heart is the chief danger spot. It is not the voltage but the current which passes through the heart which is the important thing. Though with a given body resistance, an increased voltage causes an increased current to pass. It has never been determined with accuracy, just how much current can pass through the human body with safety. It doubtless varies with individuals. High voltage causes paralysis which may stop breathing, and even the heart's action. First aid in lightning stroke should be *artificial respiration,* the same as is used to restore a drowning person.

No danger results when a comparatively large current flows through the lower trunk alone, but as low a pressure as 65 volts has been known to prove fatal, when it passed through the thorax.

The resistance of the skin varies with its dryness, moisture, greasiness, and by the area which is in contact with an electric conductor. A bare wire carrying our ordinary lighting current at 110 volts or 220 volts pressure may be handled safely if the skin which the wire touches *is dry* or if the person's boots by which the current leaves are *dry.* But let the hand be wet with water or with perspiration or let the person stand on damp floor or ground, then enough current may pass through the heart to paralyze it, and death will occur suddenly. Most fatalities from industrial currents comes from those at 500 volts to 5000 volts pressure. People who have received shocks from a 10,000 volt current have lived.

At low voltages the alternate current is three to four times as dangerous as the direct current but at high voltages the direct current is the more dangerous. It is safe to pass a current at

several hundred thousand volts pressure through the body if there are over 10,000 alternations per second. Three-tenths of an ampere causes death at low rate of alternations but three amperes can safely be taken if the alternations are half a million per second. With wet hands and feet the resistance of the human body may be from 1000 to 1500 ohms. This is not much of a resistance for the lightning at its great pressure to overcome. A person standing isolated on moist soil makes an attractive target for the lightning. If taller objects of equally low resistance are nearby the person may escape or receive only a minor shock.

There is a superstition that "lightning figures", found on the skin of a person struck by lightning are mysterious photographic reproductions of trees, landscapes or objects in the neighborhood at the time the person was struck. But the various figures produced doubtless show the distribution of the high potential electricity in passing along a poor conductor and the consequent burning along a ramifying path.

If you are out of doors in a very severe electrical storm, it is well to observe the following rules for your own protection.

1. Keep away from wire fences. They may carry a dangerous electrical charge long distances. Cattle in pastures are frequently killed from the neglect of farmers to ground the wire of the fence.

2. Keep away from hedges, ponds, and streams.

3. Keep away from isolated trees. Oak trees are frequently struck; beech are seldom struck. It is safe in a dense forest.

4. Keep away from herds of cattle and crowds of people.

5. Do not hold an umbrella over you.

6. It is safer to sit or lie down in an open field than to stand.

7. Drivers should dismount and not stay close to their horses.

8. Do not work with any large metal tool or implement.

If you are indoors.

1. Keep away from the stove and chimney. The hot gases from the chimney may conduct the lightning to and down the chimney.

2. Do not take a position between two bodies of metal as the stove and water pipe, for example. An exception to being near metals is the case of an iron bed. One of the safest places is on a mattress in an iron bed, provided you do not touch the metal. The metal surrounding you makes a safe cage which will prevent the lightning from reaching a person inside.

3. Do not stand on a wet floor nor draw water from the well or faucet.

4. Do not stand directly under a chandelier, near a radiator, nor on a register.

5. Do not use the telephone.

The telephone instruments and users to a large extent are protected by use of a device—*the lightning arrester.* This consists of a ground wire coming close to the telephone wire but not quite touching it. The gap between is enough to prevent the current used in telephoning from passing across to the ground, but when the wire receives a high charge from lightning, the potential is so high that the charge easily jumps across the gap and passes to the ground instead of passing through the instrument and finding some other passage to the earth. You will observe that telephones properly installed in your homes are not placed where a person in using them could at the same time make contact with a register, radiator, or water pipe.

You are invited to send to the editor, an account of any experiment or demonstration which you have found useful in explaining any subject relating to lightning.

Some Experiences in Teaching General Science and Physiography[1]

BY HARRY A. RICHARDSON, Teacher of General Science and Physiography in the Woodward Avenue Junior High School, Kalamazoo, Michigan.

General Science was introduced into the Kalamazoo public schools a year ago last fall. We have it in both the seventh and eighth grades. In the seventh grade it is required of all pupils and comes two times a week; in the eighth it is an elective and comes four times a week.

We use the text book as a background and build up around it. And we are frank to confess that it takes some building as we have not yet tried out the book that exactly fits our conditions or meets our requirements. One reason for this, aside from the in-

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[1] Abstract of paper delivered before the Michigan Schoolmaster's Club at Ann Arbor, in March, 1916.

trinsic faults of the books themselves, is because the conditions require material for two years of work, and that it be put in language within the capabilities of the pupils in the grades where the subject is taught.

We do not begin at the front of the book and take up each consecutive chapter in order, but select the ones in the book which we think most suitable for the grade of pupils with whom we use them.

There is no laboratory work in our course, the experiments being entirely demonstrational. We feel that the pupils are not mature enough to undertake such work, that the method for performing the experiment would monopolize all the thought at the expense of the truth to be illustrated. But without a doubt we shall outline some work to be performed by the laboratory method, such as, for example, the taking of measurements, the examination and testing of simple rocks and minerals.

But even now, in the performing of an experiment for demonstration, a pupil or group of pupils is sometimes called upon to give assistance or sometimes to perform the whole experiment. And in *all* discussions of the experiments performed, whether by the teacher alone or with the aid of some of the pupils the pronoun "we" is always used, and thus they are made to feel somewhat as though they themselves had done all the actual work.

There are those who think that it is necessary to have a great quantity of ready made and expensive apparatus for teaching general science, but my own experience does not bear out any such idea. By the exercise of a little ingenuity, and with the required materials, many a piece of apparatus can be fashioned, which in many ways is better than a more expensive, ready made one. For one thing it is liable to be simple, hence the principle to be illustrated is not apt to be obscured by the complexity of the apparatus. It also has a certain fascination about it. The pupils are almost sure to ask if the teacher made it himself and on being told that he did so, seem to take renewed interest and are impressed with the fact that the principle which the piece of apparatus illustrates, is not afar off and beyond the range of their own experience, but is very near to them. And many times a boy is willing, yes. anxious, to bring to school for the use of the class, some apparatus which he has made, or that has otherwise come into his possession.

Almost all our classes in the eighth grade and some of those in

the seventh, are required to keep a notebook in which a record is kept of each experiment, with regard to the purpose of the experiment, how it was performed, the results obtained, and the conclusions drawn. And it is gratifying indeed to see the results accomplished in some of these books. In our eighth grade, mechanical drawing is also an elective, and thus some of our science pupils have an opportunity, in making their drawings in their note books, to use the knowledge and practice of the mechanical drawing.

The work in the seventh grade deals largely with facts, although a number of principles are brought out and dealt with rather lightly. In the eighth grade more principles are studied the farther we go. This was well illustrated in a class last semester, in which class, for lack of sufficient advance material in our text book we early in the semester went back to review and spent about twice as much time on it as we did on going over this same material in the seventh grade.

Many times I have heard professors of science in high schools and others in normal schools and colleges, assert that the things taught in general science can be nothing but bare, simple, isolated facts, that the children of that age cannot grasp, remember or apply general principles. Some of those persons have had little or no experience in teaching science to pupils of that age. It would surprise some of those persons I am sure, to see the ability of pupils to grasp principles and do real logical reasoning concerning them. Of course it goes without saying that the principles must be given in a simple manner and entirely within the grasp of the pupil for whom intended.

Of late I have been reading with great pleasure and interest a recent book entitled "Methods of Teaching in High Schools" by Dean Parker of the School of Education, Chicago, in which he points out that children have long been thought by many people to be without the ability to reason, but experience shows such opinions to be false. It is true, he points out, that they make mistakes in their reasoning, but so do a great many grownups.

How pupils often possess the ability to make application of a fact or principle learned, was well illustrated in one of my seventh grade classes. The subject we were studying was water, and we had just brought out the fact that water dissolves gases, which are driven off on its being boiled, when one boy exclaimed, "Oh, now I understand." Then he told us how some days before, he

had emptied the water out of the globe containing the gold fish, and in his haste had refilled it with water from the tea kettle, which had cooled only shortly before, and on arriving home at noon, found that the fish had died.

In all topics studied we endeavor to make every day applications, to connect up with the out of school experience of the pupil. When studying a certain topic, pupils are often asked to search for relevant material from sources in their every day life, and it is truly wonderful to see what a wealth of contributions are made in this way.

For the first year or more, we seldom if ever say "This comes from chemistry, that from physics, the other from mineralogy." But in the latter part of the eighth grade, the question of the science from which the subject matter is taken, or what is the ground covered by a particular science is not uncommonly asked.

Wherever and whenever the opportunity offers itself, which is not so very frequent, we try to correlate the work with arithmetic, which we think is done with profit to both subjects.

It is our experience that seventh and eighth grade pupils are intensely interested in science and are able to make application of some of the principles learned. The work of general science has been the means of holding in school more than one boy who would have, for lack of interest, dropped out, or attended because compelled to do so. In this connection I might say that other boys have told me that the work in general science has awakened an interest within them, not only for this subject, but has caused them to care more about their other school work than before.

As to our methods of teaching physiography, they are not much different from those in common use elsewhere.

Although we have three junior high schools and one high school, which latter is comprised of all four high school grades, for the last two years the work in physiography has been limited to Central High School and Woodward Avenue Junior High School.

Our course, as in most places, is found in the ninth grade and covers one year of time. The text book employed is Elements of Geography, by Salisbury, Barrows & Tower. An attempt is not made to cover that entire book, but the greater part is gone over. Thinking that it better lends itself to the beginner in the subject, we take up materials of the land and their uses, and the development of the various land forms in the first half of the ninth

grade and the mathematical geography and climatic factors in the latter half.

The number of class recitations per week is four, with one laboratory period. The laboratory exercises are first worked out by the pupil on rough paper and are handed in for inspection, after which they are returned to the pupil for correction of errors. When these are properly made, he is directed to copy the whole exercise in its corrected form and hand in for grading.

Opportunity is occasionally offered for performing class room demonstrational experiments and whenever of sufficient import the pupils are required to write them up as a part of their exercises.

If the school program is so arranged to allow it, field trips are taken with the beginning class in physiography a few times during the semester, on which trips, different soil structure and formation, stream movement and action, different land forms and whatever is considered of relative interest to our subject, are pointed out.

As to my personal preference of general science or physiography, I have not any. But I do have definite ideas as to this question: "From which does the pupil at this age obtain the greater value; which one is better adapted for forming habits and ideals, which he will carry with him through life?" My answer is in favor of general science.

Superintendent Francis of Los Angeles at the Detroit meeting in February said that education does not consist in simply passing the "minimum essentials," but in living, in making the boy able to talk intelligently regarding the things about him; that the science of boys and girls in handling snakes and plants is almost equal to that of the laboratory expert.

With great significance, it seems to me, I hear the echo of this same thought coming from across the water. For in the November 18th number of *"Nature"* published in London, in the leading editorial entitled *"Science for All,"* a plea is made for the schools to cease trying to make research experts out of the comparatively small number of pupils who have sufficient courage to elect the sciences; not to treat them in such an intense, abstract and forbidding manner, but to broaden them out and allow the average pupil to see some of the glories and beauties of the various sciences and better appreciate life about him.

Many times teachers and laymen have been heard to say, "This

taking of one fact or principle from one science, and another from some other and putting them together, I call a hodgepodge. Can that be called science?" The answer I take almost verbatim from Dean Parker's book, mentioned above: "If a student who is presented with a problem concerning ventilation, for example, has to search for relevant material from various sources he may be doing the highest grade of logical, reflective thinking. If he keeps his problem clearly in mind, if he searches for evidence in an unbiased manner, if he rejects irrelevant material, if he arranges and organizes his ideas, if he formulates and verifies his conclusions, he is being logical in the highest sense, he is being scientifically minded, he is acquiring skill in the use of scientific method, and he is on the right road to become a scientist.

And right there, to me, is one of the greatest values to be gained from the study of general science. Dr. Bagley has made the point that habits are transferred only when they become conscious ideals. And I firmly believe that this subject offers far greater possibility in this regard for pupils of the junior high school age than does the science of physiography. It provides a great possibility for a training in scientific method to the end that the pupil may appreciate the value of scientific knowledge in solving the problems of later life, and may use the scientific method in their solution. This is an ideal which I strive to hold before the pupils in my own classes."

Obstacles in the Path of General Science

Frank M. Greenlaw, Rogers High School, Newport, R. I.

Few subjects added to the high school curriculum in recent years have attained such widespread popularity as *general science.* The pressure for courses of study which eliminate latin and algebra from the work of the first year of the high school and the increasing tendency to regard typewriting and stenography as better placed in the later years of commercial courses have created a demand for work which can profitably be given in the first or second year. Physical geography, commercial geography, biology have been tried but not generally accepted. Now comes general science; and administrators all over the country have hailed this as a convenient means of filling a program, a receptacle into which all pupils might be gathered who were not fitted for the

'higher things' of the traditional routine. Herein lies one of the chief dangers to the lasting success of the new movement.

Further, there is serious objection to the introduction of undifferentiated work in a school which is professedly higher than an elementary school. There is naturally wide difference of opinion on this point; but the strong tendency towards early differentiation of courses which has led to the establishment of junior high schools carries with it differentiation of subject matter in senior high schools. Where such separation of grades is accomplished, it appears that general science belongs to the lower rather than to the higher group of grades.

A third difficulty arises from the large number of pupils for whom provision has to be made and the lack of a broad equipment on the part of many teachers who are called upon to teach general science. It has been well said that this work demands the best teaching that the science department has to give. Perhaps no other subject is so well adapted, in proper hands, to arouse the self-activity of the pupil, to cultivate his initiative and resourcefulness. Few, if any, subjects lend themselves so readily and helpfully to social applications. The girl or boy of today who cannot run an automobile is almost an exception. Pupils often know much more about wireless than their science teachers. Here are basic attainment and interest which are duplicated in many fields. Even the 'movies' provide a starting point if attention is shifted to the projection apparatus or the cinema camera. And that teacher is wise who sets the heroes of modern science over against the lurid heroes of the screen. What I wish to suggest is that the work in general science, to be worth while, must start from and follow the science experience and interest of the pupil, that so far as possible the pupil should determine the direction of the work and share in responsibility for the success or failure of the result.

There will be some administrators who prefer the comfortable order of things in which the teacher assigns each day three or four pages of the text for tomorrow's recitation. Let us be charitable. Perhaps we too once followed the easiest way.

General Science Bulletin

Preliminary Draft prepared by the Massachusetts State Committee on General Science.[1]

Preface

General science is the outcome of a distinct movement to reorganize and readjust science instruction so as to meet the needs from twelve to sixteen years of age, in the two upper grades of the elementary school and the first year of the high school, or in the junior high school. The purpose of this instruction is to give a knowledge of physical environment, including earth formations and processes, the heavenly bodies, the atmosphere, weather and climate, various materials and their changes in substance, form and position, natural forces, and their use or control by man in such industries as agriculture, manufacturing and transportation.

The term general science, is commonly applied to several undertakings widely differing in content, organization and methods employed by teachers, in text-books, and in courses of study. Justification for the term general science may be had in that in all cases material is drawn from the entire field of nature, without regard to the artificial limits set up by the special sciences, such as chemistry, physics, biology, meteorology, and astronomy.

This term may also be regarded as including all the efforts which are actuated by a spirit of protest and reaction, not to say revolt against the extreme specialization in the teaching of science, particularly in the earlier years of the high school, which emphasized the mastery of subject matter and drill on formulas, rather than adaptation to the interests, capacities and limitations of the pupil.

There is also manifest a desire on the part of many high school teachers of science to secure large freedom in regard to both content of subject and method of instruction. Such freedom is impossible, when definite, uniform standards are imposed on

[1] This committee consists of William Orr, formerly Deputy Commissioner of Education, chairman; Howard C. Kelly, High School of Commerce, Springfield and W. G. Whitman, State Normal School, Salem. The report as here printed, is not in its finished or final form. Criticism and suggestion are invited by the committee.

high schools from some outside authority, either public or private, as by an examination system.

Doubtless this movement for a new type of science instruction owes its origin, in part, to dissatisfaction with results of existing modes of instruction on the part of both teachers and public. This dissatisfaction has been accentuated by the decline in the proportion of pupils in the science courses in the high schools. That in an era in which science was assuming such an increasingly important place in the thoughts of men and in the processes of industry, there should be a declining interest in the study of natural and physical phenomena by boys and girls in their teens was regarded as constituting ground for serious criticism.

There was also evidence at command to show that with all the elaborate equipment of high school laboratories, and provisions for instruction in the sciences, there prevails a very widespread ignorance among the public of the most elementary facts and processes in the world of nature.

As a result of these influences, many experiments are now being made to outline a more satisfactory procedure. Some of these enterprises are conducted with an imperfect understanding of the actual problems and conditions involved, and are likely to prove futile. In other cases, even though the instructor may not be wholly clear as to his aims, the conduct of class work has improved, and a finer interest on the part of the pupil has been secured because of the new spirit in the school.

The practices in organizing courses in general science are as yet endlessly varying. Thus, there is often an absolute dependence on text-books; there is often a failure to adequately define aims and purposes. The teacher is prone to revert to routine methods of topical presentation. In fact, there is grave danger, unless a definite statement is made of the aims, purposes and principles on which a course in general science should be based, that the present promising movement for a better teaching of science in the earlier years of the high school will fail to make progress because of a lack of definite direction. and that there will be a reaction toward traditional methods of instruction which, despite their shortcomings, were directed toward clearly defined ends and aims, even when these were not valid as regards the interests and needs of the pupil as an individual, and as a member of social and civic groups.

This Bulletin is intended to give a statement, in somewhat summary fashion, of the aims of a course in general science, and to define the place of such a course in the program of the formal schooling of boys and girls from twelve to sixteen years of age. The Bulletin also outlines the principles on which the selection and organization of material are to be based. Examples and illustrations are given as suggestions, and in no sense as parts of a syllabus.

The methods of conducting class work are outlined, and a statement made of desirable equipment.

A list of projects is presented, as suggestive. It is not intended that the Bulletin should in any way be looked upon as giving a definite outline for a systematic course of study.

INTRODUCTION

The term general science, as used in this Bulletin, denotes a course of instruction dealing with material drawn from the natural environment, for pupils of ages over twelve and under sixteen, particularly when such pupils are segregated in an intermediate or junior high school in which the teaching is done on the departmental plan. General science may or may not be a subject required of all pupils, although it is highly desirable that every boy and girl of the ages above given should have some opportunity for instruction in the phenomena of the natural world. A course in general science, however, should be open to all such pupils. Any pupil for whom work of this kind is decidedly undesirable should not be required to pursue the course.

General science should include a great variety of work with the view of interesting pupils of different aptitudes and interests. Many of the pupils who pursue general science will not complete their high school courses. Others will be able to take one or more special sciences, as physics, chemistry or biology. The following program is suggested for the sequence of science in a secondary school program of instruction:

General Science for pupils of ages twelve to sixteen.—Grades 7, 8, and 9.

Biology.—Grade 10.

Physics or Chemistry.—Grade 11.

Physical Geography, advanced Chemistry, advanced Biology, advanced Physics.—Grade 12.

In a small high school, it will not be possible to offer advanced courses. In the public schools, the pupil may be offered as an alternative for general science, work in a foreign language, in history, mathematics or manual training.

The material in a course in general science is drawn from natural phenomena and processes, without regard to their classification under the head of special science.

The following time allotment for general science is proposed: Five periods a week for a year, making for the full high school year two hundred separate exercises. Individual laboratory work is desirable, although not essential.

Text-books should be used for reference purposes, and not as outlines of courses. The teacher in each school should largely determine the content of the course and the order in which the different types of material are considered.

General experience goes to show that twenty pupils to a division constitute a number with which most satisfactory results can be secured.

Aims of General Science

General science constitutes an element of liberal education. Its function is to give an opportunity for the systematic expression of the spontaneous interests, native curiosity and inherent desire of the pupil which lead him to crave a knowledge of natural phenomena, including the properties of material substances, forces and processes, and particularly the uses man has made of natural forces, and his conquest of the physical universe, both as to discovery of its secrets, and control of its energy. The principal purpose of general science is cultural.

As a result of courses in natural science, the pupil should be able to read more intelligently and with greater interest, articles on science in magazines and periodicals, and scientific books of a popular character. He should read with a greater understanding much literature which abounds often in scientific allusion. Examples of such literature can be found in the writings of poets, as Tennyson.

Apart from these main aims of general science, certain by-products may be naturally expected which come under such aims as lie within the immediate field of physical, social and vocational education.

In some instances, the work in general science may have in mind aims that come under one of these three heads, but if so, this practice should be clearly in the mind if the teacher. Any attempt to seek to secure several aims at one time is likely to lead to confusion and poor instruction.

Thus, it may be possible in a course in general science to lead pupils to understand the importance of good food; of a supply of pure water. Their sense of civic responsibility may be developed by showing, through certain undertakings in general science, how scientific knowledge and method can be utilized in public sanitation and hygiene. Contact with various industries may give pupils some insight as to their capacity in different vocations, or certain parts of the course in general science may be used for this specific purpose.

The main purpose of the course, however, as stated above, is that the pupil may deepen and broaden his interest in natural phenomena. General science should promote a wide outlook upon the world of matter. The work should be so organized and conducted as to give large mental satisfaction, which comes from the gratification of real needs and desires. There should be an increased appreciation of the delights and satisfaction to be found in the study of nature.

In view of the above considerations, it would appear clear that the purpose of general science is not to give the pupil, in any sense, a mastery of a certain body of organized knowledge, or a command of formulae; nor is it intended to develop expert scientists, nor primarily to give training in scientific method. Rather, general science gives the largest possible opportunities for the exercise, along the line of the pupil's interests, of the inherent desire to know more of the universe in which one lives.

The Scope of General Science

General science draws the material for its courses from the entire physical and natural environment of the pupil, particularly, from that which is within the range of his immediate experience. The teacher of general science, however, is at liberty to direct the attention of the pupil beyond those objects and phenomena that come within his immediate environment. In selecting material for the course, the teacher should not recognize any of the formal divisions of human knowledge concerning nature, such as chemis-

try, physics, biology, meteorology, nor should the technical terms used in connection with these divisions be, as a rule, emphasized except as designating objects or classes of objects or forces.

Inasmuch as most teachers of science have gained their knowledge of the physical universe through instruction in the special sciences, it will not be altogether easy to adjust a viewpoint in which one deals with the natural environment, as a whole. It will be necessary to keep clearly in mind that the pupil is to be brought as directly as possible into touch with the objects and processes, and that nomenclature, formulae and technical terms should not be permitted to interfere with such direct observation and experience.

General science in its scope does not, morever, undertake the mastery of the material that would come under some particular science; in fact, the term—mastery of science—as used in the schools is really a misnomer, as such an accomplishment by a pupil is practically impossible; moreover, it is doubtful whether the ability to hold in memory a certain amount of organized material does really constitute the mastery of a science.

Any subject or theme taken up in the work in general science should not be treated exhaustively. Many projects available for use in general science relate to processes and changes which in many of their aspects are beyond the comprehension of pupils, such as the explanation of why salt dissolves in water; why sap rises; the reason for the action of sulphuric acid on zinc containing carbon. On the other hand, it may well be possible for the child to apprehend immediate concrete action and processes, and the conditions determing such action, as the expansion of water on freezing; the effect of heat in hastening solution; the effect of moisture on the germination of seeds. It is well within the scope of general science to bring about an interpretation of those natural phenomena which come within the range of the experience of the pupil or in which pupils are already developing an interest. The material, however, should not be presented in a technical form, nor should large place be given to quantitative standards and calculations.

It is important that a pupil, when finishing a given subject in his course in natural science should be left with the impression that much is yet to be learned. It may be that in some instances the pupil is to be encouraged to pursue his researches even further,

but this method should rarely be followed in the case of the class as a whole.

General science should give information and added experience in all the fields of nature. In recent years, there has been much neglect of the study of those natural phenomena included under the head of astronomy, such as the heavenly bodies—their changes in position and appearance. The suggestion is made that the study of the sun, moon, planets and of the changing aspects of the heavens should be given a prominent place in general science.

It should be noted further that in dealing with problems in real life the student does not have any record of those artificial divisions by which special sciences are constituted.

It will be found that pupils, as a rule, are much less informed on natural phenomena than is generally understood. Many superstitious ideas remain, and there is a marked ignorance as to the most obvious of nature's teachings in common things.

Not enough attention is paid in teaching, as a rule, to showing how answers to questions and problems on nature can be secured from the dictionary, encyclopedias, and readable texts. Information on scientific matters should be made easily accessible to the pupil.

The teacher of science to boys and girls in their early teens should not limit the courses to a given number of subjects or experiments, or to statements of fundamental principles.

Material Used in a Course in General Science.

The subject matter of a course in general science, as above stated, is to be drawn from the natural and physical environment of the child. In whatever form this material is gained by the child, by reading or observation, by demonstration by the teacher, or by experiments of pupil or teacher, there should be established a very close connection with the concrete experience of the child. The following classes of material are presented as suggestions to the teacher in organizing the work of the class for a given year:

(a) Observation and study of phenomena of local character, including earth formations, minerals, rocks, trees, plants, crops, various household appliances and processes, weather observations, animal habits and seasonal changes. On the farm, one will find many machines and devices that will repay study.

(b) Demonstration by the teacher, including lectures and in-

formal talks, illustrated by experiments, lantern views, charts, diagrams and moving pictures and photographs.

Experience shows that a certain dramatic element can be introduced into such demonstrations. The effects in stimulating and arousing the interest of the pupils in the particular subjects under consideration are most satisfactory.

(c) Material gained by experiments made by the pupils in order to secure an answer to some particular problem which arises in connection with some phase of general science.

(d) Books dealing with science, such as natural histories, general descriptions of nature and scenery, text-books, popular and technical articles in magazines and newspapers, the Government reports, trade catalogues, particularly those containing descriptions of devices and machines, gazetteers, Board of Health reports and catalogues of firms manufacturing or selling motor boats, automobiles, gas engines, refrigerators, hot water heaters, hot air furnaces, and other productions in which one finds illustrations and applications of scientific principles.

Care should be take in recommending reading for pupils not to call the attention to books and articles which are of an excessively technical character, as only few, if any pupils are likely to find interest in such work.

The reading of the pupil should be directed along some particular line, especially within the field of his own interests. There is danger, unless there be such direction, that the reading will become desultory and that little will be gained by the pupil in the way of information. Whenever pupils find material in their reading which makes an especial appeal to them and arouses their interest, they should be encouraged to bring such material of a scientific character to the class, and to present reports upon the same.

Note. The public service departments, such as those in charge of the water department, fire protection, health, good food, etc. will afford much material in the shape of talks and reports to be used in a course in general science.

While care should be taken in general science not to expect overmuch in the way of the mastery of generalizations by the pupil, occasions will often arise in which it will be possible out of very concrete cases to develop generalizations.

The teacher should undertake to find out in what undertakings

pupils of these ages are especially interested, and also their needs.

A number of type lessons should be organized, showing how material is handled under each one of the above heads. It is desirable that there should be a bibliography of reading material, and also a list of commercial appliances that are available for class study.

It must, however, be accepted that the test of the success of a course in general science is not found in the amount of material gathered by a pupil, nor in the statements committed to memory. If the interests of the pupils are broadened and deepened; if their range of study is widened; if more and more they bring material into the class; if there is an increasing disposition to report results in note-books, and to make reports; in other words, if there is a manifest gain in self-activity, then the teacher may accept the work as successful.

Note. In addition to the above material for reading, note should be made of the U. S. Government publications, such as those relating to National Parks; those should be selected which are in a readable form. The use of leaflets—each dealing with some particular phase—is also recommended. A school may gradually build up much material of this kind as the result of the work of individual pupils. Attention is called to the leaflets published by the Cambridge Botanical Supply Co., with such titles as: "How Soil is formed." "The Work of Plants," etc.

The material in a course in general science should be drawn from many fields. It will, as a rule, however, include facts and processes, inventions and machines which are of common interest in the life of the pupils. The material will be largely local. In some cases, the project will be suggested by some unusual local experience in the community or in the homes of the pupils, as: some insect plague, a great fire, a flood, a severe storm, the industries that predominate in any given community, as electrical appliances, paper-making, iron casting. Local natural phenomena may also be drawn upon for material, as: tidal wave or river action; or local enterprises calling for scientific knowledge, such as building a water supply. Temporary material may be either local, national or world-wide, suggested by some particular circumstances, as: a low water supply in a community would suggest the use of filters, and the various methods of purifying water; the use of poison gas in war; the sub-marine.

Apart from the knowledge of facts and processes, the pupil should, in a course in general science, gain a command of certain tools and devices, such as the use of measuring glasses, graduates, balances; of means of measuring, such as rulers.

Practice should be given in the systematic arrangement of data in tabular form, and also the use of co-ordinated paper, and the plotting of curves.

A by-product of no small importance is in the field of vocational guidance, as the pupil's attention is directed to various lines of activity wherein he may discover his bent.

(To be continued.)

General Science in the Junior High School at Rochester

Harry A. Carpenter, West High School, Rochester, N. Y.

Part I. Organization and Aims.

The content of any well organized general science course must be determined by a careful consideration of the actual home, street, school and community environment of the pupils, together with the probable vocations or professions they may pursue. A general science course built around these needs will not merit the criticism of "a general science dominated by a specialist in any branch of science."

The general science course that does meet the above conditions will produce marked results as measured by training, information, hygiene and sanitation, and better health of pupils, only when conducted by teachers of the highest skill and tact; teachers who are willing and able to venture off the well trodden paths of the classic special science.

In developing the general science courses as we are now giving them in our first junior high school we have given much thought and study to the needs and aims of boys and girls as indicated by their home environment and working conditions, as suggested above.

As a successful general science course—no matter what year it is offered, must dove-tail with what ever science training precedes and comes after it. I will outline the plan that we are pursuing today. Let me take the opportunity at this time to

make clear that our work at Rochester is still in the experimental and formative stage.

The first year of actual presentation of the courses in the junior high school was preceded by regular Saturday Normal Class work for teachers throughout the year. At these meetings they attempted to anticipate and prepare. The past year of actual experience with the problem has reinforced some of our ideas and undermined other preconceived notions. The average grade teacher is wholly unfitted by science training, information and attitude to handle general science work effectively. They must therefore be given special help for the work and only the most efficient teachers should be used.

The general science teacher must love the work, must be buoyant and energetic. She must at the very outset gain the complete confidence of the children. She must be a science worker with them and yet a leader.

The population of the section of the city that contributes to the Washington Junior High School consists largely of various types of foreigners: Italian, Polish, German, Hungarians and few English.

The children from the sixth grade from seven contributing grammar schools enter the junior high school as the seventh grade and remain for three years—7th, 8th and 9th grades, the ninth grade being comparable to the 1st year of the regular high school. The senior high school consists of three years—10th, 11th and 12th.

The children presenting themselves for admittance to the junior high school show all the potentialities one would expect knowing their environment. A few are unusually bright and alert, some give evidences only of a passing interest in things educative, while a majority perhaps are rich with family tradition and superstition.

The psuedo-science work of the grammar schools consists of the usual physiology and hygiene; geography as it touches physographical, astronomical and meteorological features; together with some nature study in a few instances. The content of the nature study work depends largely upon the personal interests and ability of individual teachers centering about birds—insects—trees—flowers, etc. In general the tendency of the teaching is toward information of science topics, rather than training in scientific methods and attitude.

In the Washington Junior High School, all entering pupils-7B

are given work in elementary science two days a week for 90 min. each day. The content of this and succeeding courses will be discussed under separate heads.

Before leaving the 7B grades the pupils must choose between the academic course for both boys and girls, and household arts course for girls and industrial arts course for boys. This choice is made only after a thorough study of the individual case and thorough co-operation of principal, teacher and parent. It is important to state however, that misfits in the 8th and 9th grades are transferred as the need arises.

The content and character of the science work for the 7A—8th and 9th grades is directly influenced by the needs of the particular department concerned, but the underlying aims and methods are the same. The academic pupils continue the elementary science in 7A as started in 7B grades. For these pupils the science work in 8B and 8A is limited to hygiene organized as a part of their regular physical training.

In the 9th grade the commercial and academic pupils are given general science three days each week for the entire school year. Each day's period for this science instruction is 90 minutes long.

In the industrial arts department, the boys are given general science one day each week for 90 minutes in the 7A and 8th and 9th grades. In addition to this, 30 minutes of physical training time is devoted once a week to science of hygiene and sanitation.

The household arts girls receive science instruction for two periods of 90 minutes each, every week during the 7A and 8th and 9th grades. This work continues the work started in the 7B but is shaped to serve the needs of the household arts girl more particularly. We belive that this science training is of genuine importance to these future home makers.

In order to show in a general way our plan of attack in all the science work I give below a few suggestions relating to the 7B work given to all entering pupils.

We are attempting to give these pupils the beginning of a training in science methods, thought and procedure—a training that will be of distinct service to each one no matter what road through life they take.

We select as vehicles for this training such topics as will furnish useful and practical information without regard for the particular special science of which it is a part.

The contents of all courses for the 7B and 7A classes are arranged in groups, and the order of the groups is dependent to some extent upon the seasons. While these groups are not necessarily inter-dependent, yet the information and training obtained by study of one group is made to play a definite part of the attack, by the pupil, of a succeeding group. Each group is composed of a few closely related and inter-dependent topics.

In the presentation of any topic for example, Rocks, care is taken not to introduce any subject matter that is beyond the mental grasp of the pupil just because it happens to be of technical significance. Technical terms and classifications are omitted unless they can be clearly presented to, and comprehended by the pupils.

The first group of topics for the early fall in the 7B sections includes rocks, soil and rivers. We do not have the children study rocks, for example, from the mineralogical standpoint, nor the geological classification but we do want these boys and girls to know whether they are looking at or handling a lime-stone or a sand-stone, etc. We want them to know the commercial sources of these building stones. We want them to be aware of their building uses, and the relation of characteristics and use, or in other words we want these children to know ordinary building stones from an every day practical standpoint.

We endeavor to see to it that they get this information in such a manner as to give them training in observation and scientific methods of attack. All study of these topics is as far as possible preceded by out-door or laboratory observational work, sometimes by the individual alone and sometimes in class groups supervised by the teacher. All material collected and brought in by pupils must have its written "story" giving all information concerning it, and this information must be organized.

In all the science work the study, as well as the laboratory work is under the direct observation and supervision of the teacher, and it is possible therefore, to obtain more satisfactory results than after the older plan of allowing the student to study by himself. The idea is well expressed by the note received by a teacher from a care-taking parent, "You teach John his geography and I will hear him say his lesson." The fact is, we teachers spend too much time "hearing lessons" and not enough time teaching boys and girls. It is of prime importance to teach them how to study.

The 90 minute period makes this method possible and much skill is needed to properly balance, study, discussion, demonstration and laboratory work.

Following the group of topics mentioned above is a group of topics including the study of Air and Fire, and in these topics the elementary notions of combustion and combustibles is given. These facts however, are not taught from the standpoint of specialized chemistry, but from the direct view point of the boys and girls experience. We take the experiences which they have, and add other experiences by means of laboratory and observational work. We correct their wrong ideas and put in their stead accurate scientific knowledge covering the topic. Topics of this sort lend themselves readily to health and sanitation applications; the study of fire risks and fire control. Here too is an opportunity to instill in the pupil a conception that he has a duty to himself and others not to be careless since personal carelessness is the big cause of disease, accidents and fires.

In all the science work the pupil is made to believe that he is an important part of the whole civic unit and that each must do his full share in civic betterment.

One noticeable feature in the usual science scheme of today is the lack of opportunity and incentive for a pupil who shows unusual interest or ability in a special field, to continue the study of that subject without interruption, and at the same time without undue encroachment of the time he should devote to other fields of study.

For example, a boy or girl may early in their science study exhibit unusual activity of thought initiated by elementary study of the stars and planets. In fact I have in mind two 7B boys especially, who have shown remarkable aptness for things astronomical. I ask, what provision is made by a science plan for boys of this sort to continue the study of this, their hobby? All boys and girls show a liking and ability for some one thing.

What happens in most cases is what I have been forced to say many times in the past. "Yes, yes David, I am glad you like astronomy, and I advise you to read books and when you get to college (if he ever does) you can study more astronomy." What does David do? Just what all the others do, drifts through other interests, farther and farther away from his first real interest and may be a great astronomer is lost to the world.

Just so far as our science teaching makes no provision for the exceptional pupil to pursue the study of a particular interest, to pursue a hobby if you will, just so far does our teaching fail.

How can this provision be made? We are trying to solve this problem in Rochester through the medium of carefully worked out Science Bureaus or club sections. This is of course entirely voluntary work on the part of the pupil, but is under the direct supervision of a trained teacher. Through these Science Bureaus we hope to stimulate the formation of a hobby, to give an opportunity for David to continue his study of astronomy along with other boys and girls in the same line. In this way the ordinary gaps in the pupil's astronomical interest will be filled, and he will continue to climb his chosen hill.

In this age of specialization to use the wise words of one of my college professors, "We must know something about everything and everything about something". We must have our pupils get about this "knowing" early.

I feel that the full measure of success of any general science work in the grades or high school will be obtained only when that general science work is supplemented by the carefully organized club plan which will furnish the stepping stones across the streams of other important activities, and allow the boy or girl to give uninterrupted and directed attention to a special interest.

The laboratory part of science work in the past has shown an interesting growth and variation. Originally all laboratory work was of the nature of teacher's demonstrations, and was calculated to inspire awe on the part of the pupil for what appeared to be the skill and magic of the teacher; or the demonstration took the form of delightful entertainment. Later much of the laboratory work of the science was performed by the pupil. He was set the task of "discovering" this or that law or relation already known to him. Still again the wave changed and the work was dominated by a demand for skill in the use of refined instruments of measurement and the application of much mathematics.

In biological laboratory work accurate drawings of microscropic objects was required, while at the same time the pupil could not make a drawing of a fish that could be recognized.

Almost any kind of laboratory work came to be the scheme of things so long as it was "individual" and "trained" for accuracy. Whether the pupil grew mentally as a result did not matter

if only his note book was neat and orderly. The laboratory work has not produced results commensurate with the time and effort spent thereon.

It is possible that too much individual laboratory and not enough group work has been given. Certain it is that with seventh grade pupils the "individual experiment" is for the most part a failure. Those young minds lack the control and attitude that is required to make an individual laboratory experiment worth while. They must work in groups under the immediate direction of the teacher or the work should be done by the teacher with the pupil looking on. It is true that there are certain experiments that may profitably be done and should be done by the pupil, but great care should be exercised if profit is to accrue to the pupils advantage. A teacher's demonstration is excusable only, if it teaches and drives home an important fact and the experiment must serve as an example to the pupil in science method, science integrity to facts and conclusions. No demonstration should be presented without first deciding just what it is expected to do for the pupil from every standpoint.

A feature of our work is what may be called our Observation Bulletin. In all classes and at all times of the year the attention of all pupils is directed toward definite seasonal observations and they are required to make careful and accurate notes. In this way, in the seventh grade for example, the pupils get a certain familiarity with the circle of events in the life history of plants, insects, birds, seasonal changes, etc., all of which can be studied later to better edvantage because of these familiar experiences than otherwise. These experiences form the basis of later science study.

In all the elementary and general science courses a fair balance between biological sciences on the one hand and physical and geographical science on the other is maintained although the work is not separated into the special sciences. The pupil's work is definitely mapped out for him, and concentrated, productive, effort is required at all times.

In the 9th year for academic and commercial pupils, biological science, as interpreting the health and hygienic needs and habits of adolescence, civic sanitation and man's environment, forms the key note. Frank use is made of helpful parts of all the special sciences, although the course is not at all divided by lines that mark off the usual boundaries of the special sciences.

The attempt is made to:

1st. Supply important and usable experiences.
2nd. Make a word study of all new words.
3rd. Give the pupil simple, accurate concepts.
4th. Require adherence to scientific accuracy.
5th. Have the pupils apply experiences and concepts already acquired, to the solving of new problems.
6th. Form habits of scientific study and methods.
7th. Develop powers of observation and awareness of surroundings.
8th. To train pupils to think.

The methods used include supervised study, laboratory work, demonstration, recitation and excursion, Science Bureaus for special study and Observational Bulletin activity.

The topics for study are arranged in groups and the information and training obtained by study of any group is made to play a definite part in the study of succeeding groups. The arrangement of groups is somewhat determined by seasonal changes. The arrangement of topics within a group is either psychological or logical as the particular case demands.

Why Science in the Grades

Percy E. Rowell, Director of Science, A-to-Zed School, Berkeley, California.

There is no doubt but that the curriculum of the grades is crowded beyond all endurance, and still the advocates of other subjects are constantly urging their introduction. Moreover, these new studies are just as desirable as many of those which are already being taught, sometimes, in fact, they are more deserving of a place in the curriculum than are some of those now present. The solution of the difficulties which are presented by this continual increase in the number of courses which are given in the grades, is one which interests, as well as stimulates all educators who realize that the mind of the pupil is shaped in the elementary school.

This accumulated mass of courses in the curriculum is rendered still more unbearable because so many of the studies not only bear little relation to one another, but even are to a great

extent disconnected from life's problems. If there could be centers of interest, around which the studies might be grouped, the result would be a greatly reduced congestion in the course of study, and on the part of the pupil, a much clearer understanding of the true meaning of his work. The pupils are busy all day long, and there can be but just so much work; the question resolves itself into one of management, of clear-cut discrimination, and of courage to undertake new plans. The demand is for greater efficiency.

This disconnectedness of studies from the problems of everyday life is well illustrated by the usual course in arithmetic. As a rule, when a pupil is in the arithmetic class, his mind and attention are concerned with arithmetic, as such. The rules and problems follow one another with a smoothness which is dangerous on account of its lulling effect upon the minds not accustomed to the subtleties of mathematical reasoning. Following the rule, the problem is easy; away from the guide, the example has a strange and foreign look. That is, such arithmetic is bookish, is cultural perhaps, but the examples are not true problems; they merely illustrate the preceding rule. Sometimes, it is true, the vocabulary of daily life is used; we are encouraged with the hope of better work only to find that while the names of the units have been changed, the "problems" are the same.

When a search is made for some co-ordinating principle, or some satisfactory means by which the various disconnected studies may be brought into at least a family gathering, it is almost forced upon the investigator that this determining guide must be the life of the pupil. This does not mean the life of any individual, but rather the composite life of all the pupils. The life of the pupil is the pupil, and his life is concerned with those factors which contribute to the satisfaction of his needs and the fulfilment of his desires. Whatever such a course, or rather such a backbone for all the courses shall be named, is immaterial; but, since it should be both exact and fundamental, it had best be called science.

A science course for this purpose should be based upon the real necessities of the child. A little thought will lead us to realize that these needs are Light, Heat, Air, Water, and Food. A study of food leads to a consideration of the sources of food, namely, plants and animals. In addition to these absolute needs,

modern life has trained our desires to require the comforts and conveniences of civilization. To appreciate the latter more fully, requires some study of Mechanics, Magnetism, Electricity, and the Arts and Industries. No one branch of science can do this, nor can science be properly taught in the grades without doing it. A blending of all the sciences, as a means for best teaching, is inevitable.

Such a course would mean much to every pupil. He would realize, to an extent never before possible, the value of remaining in school. When we consider that forty per cent. of the reasons for leaving school are within the school itself, we should pause and question whether it would not pay to teach the child from his viewpoint. Educators have been urging a certain sequence of studies because that particular order is scientifically correct, but the pupils have calmly gone their own way, which is out of school. When only twenty-five per cent. of the pupils continue on into high school, surely the school has failed to supply their needs. The pupils are the educator's public; if they are to be elevated they must first be reached. In the beginning the public must be given what it wants; later it may be given what it should have. The first problem is to hold the public.

The child is not aware of its needs, but it knows that it is doing much useless work when example after example is done at the command of some teacher. Show that child that he can use his arithmetic in some practical manner and he will gladly perform a formerly irksome task. Science, more than any other course, can supply incentives for arithmetic, drawing, reading, writing, oral and written expression and, best of all, real and creative thinking.

An Optical Illusion Makes The Moon Seem Larger When Near the Horizon

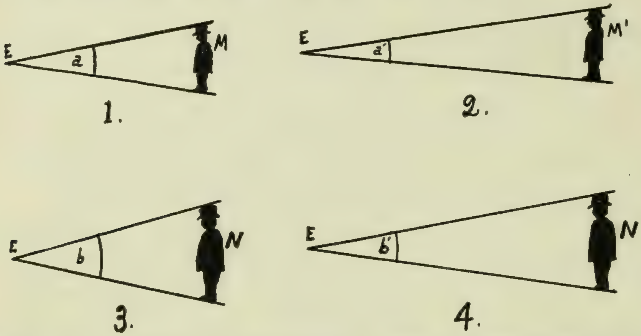
RETLAW MATHWIN.

In order to understand why the moon near the horizon, whether rising or setting, appears much larger than it does high in the sky, one must consider two things. First the angle of vision and second the unreliability of one's estimate of distances under certain conditions.

As a matter of experience in judging the size of a distant body,

we unconsciously and involuntarily consider the angle of vision and the distance to the object, then we form our judgment regarding its size.

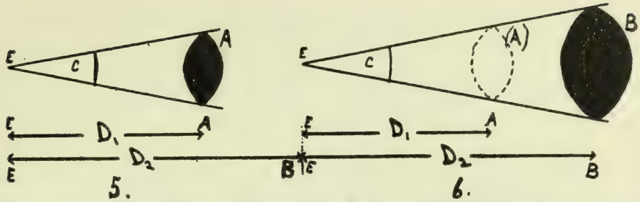
When we see a man nearby, the angle of vision is large (Fig. 1., angle a), but if the same man is at a distance the angle of vision is small (Fig. 2, angle $á$). Unconsciously we consider distance and angle of vision together and give our judgment that the height of M′ is the same as the height of M. (Fig. 1 & 2).



Figures 1-4. With the same object at different distances, the nearer the object, the greater the visual angle. With different sized objects at the same distance, the larger the object the greater the visual angle.

If a taller object N is at the same distance as M it will form a larger angle of vision (b, Fig. 3) and it will therefore appear larger than M. An object, N′, the same size as N, but at a greater distance will be in our judgment of the same size at N, for the same reason that our judgment tells us that M and M′ are the same size. N′ would appear larger than M′ because it is the same distance from the eye but produces a larger angle of vision. (b' is larger than a'). The angle of vision in Fig. 4 may be smaller than that in Fig. 1 and yet we judge N′ is larger than M because of its greater distance.

If for any reason we are deceived in our judgment of the distance, the angle of vision and the misjudged distance will produce an error in our judgment of the size of the body. For example, if an object (Fig. 5) is situated at A, a certain distance (D^1) from the eye, but we have misjudged the distance and consider it farther away, say at B, (D^2) then we interpret the size of the body by using the angle of vision actually produced by the body at A(c) and the distance to B. But an object at B to produce the same angle of vision as that produced by the body at A must be larger



Figures 5-6. A given angle of vision combined with a misjudged distance gives us a false judgment about the size of an object.

than A and consequently the object A appears to us larger than it really is. Thus are we deceived into thinking a body is larger when we are led to believe it is farther away than it really is.

In order to show how fallible one is in estimating distances, hold Figure 6 in front of different people, first covering the reading matter above and below it with white blank paper.

. . . .

A   B   C

(Fig. 6)

Ask which is the longer distance AB or BC. Nearly all will say that AB is longer. Measure the distances and you will find that they are exactly the same. The presence of a number of objects in the intervening space in some manner not well understood, causes the optical illusion.

When the moon is seen near the horizon, various objects on the earth's surface are visible and these objects in the intervening space make the distance seem greater than it is when the moon is so high in the sky that few or no other objects are visible along the line to the moon. You can further prove that it is the sight of objects along the path of vision that causes the optical illusion, by shutting them out of your sight when you look at the moon which is near the horizon. Roll a sheet of paper into a tube about one foot long, close one eye and look at the moon through this tube with the other eye. The paper effectually cuts off the vision of the objects on the earth's surface and the moon appears about as it does high in the sky. To get the effect of seeing these objects and the moon together remove the paper tube. Immediately the moon appears to increase in size.

If it were not for this optical illusion regarding distance, the moon ought to appear larger at the zenith because it is about 4000 miles nearer the observer. This greater nearness would make its apparent size increase about one-sixtieth.

Editorials

General Science at the National Education Association in New York.

The four special sessions on four different days were devoted respectively to chemistry, physics, biology, and science. One paper at least on general science was on the program for each of these sessions and many other subjects sidetracked into general science. The prominence of this subject in appearing on these different programs is significant and yet gives little idea of the keen interest given to it. In the last three sessions, nine-tenths of the discussion provoked was on the subject of general science. General science was the one live issue which interested all teachers alike.

At the physics meeting a group of text book authors discoursed on the bearing of general science on later courses in physics and chemistry. The general feeling was that the general science should be taught, not to prepare for some future course, but to develop and educate the pupil according to his capacity.

At the meeting of biology teachers, the biology committee reported through Mr. Eddy of the New York High School of Commerce, their plan for a two years course of required science. This was advocated to replace the one year of general science so widely adopted. This report was vigorously assailed by a number of speakers, the chief objection to it being that it did not remove the "vertical stratification" into special sciences which must be done to make science *general*.

At the final science session, Prof. Dewey gave us a masterpiece on "Method in Science Teaching", in which general science was the main theme. Enthusiasm for general science passed all bounds at this session until Prof. Fall of Albion College advocated general science for the grades, for the junior high school, and for the senior high school. Rather strong opposition to the extension of general science into the senior high school developed.

A pleasant and profitable feature of the New York meetings was the "get-together" dinners held at the Hotel Holley. Discussions of the day meetings were continued here; new friendships were formed, and some pleasant bantering was indulged in.

The excursions planned to industrial plants, commercial labo-

ratories and educational institutions were of much value to visitors. The science committee deserves much credit for arranging an unusually full, valuable and interesting program for the visiting teachers.

ORGANIZE A GENERAL SCIENCE CLUB

One who scans the programs of the various science teachers' associations for the past year is struck by the fact that unusual attention has been given to general science and that in some cases, more attention has been given to general science than to the special science for which the association was organized. There is but one conclusion to be drawn from this evidence, namely; that the science questions which are receiving the best thought of all our science teachers to-day are those of general science.

If we search out general science teachers and learn in which branch of science they consider themselves best fitted to teach, we shall find that some are botanists, some physicists, some chemists, some zoologists, some geographers, and some astronomers. These teachers know the best things in their own field and some of the things in other fields. It is usually more difficult for one to teach as well outside his chosen special efild. Thus, we find that one general science course lays the emphasis on chemistry, another on botany, another on physiology, another on physiography, etc. To be sure there may be some advantages in having that subject taught which the teacher can do best; but at the same time some very valuable matter which is of vital interest to the pupil, is bound to be sacrificed. Moreover there is likely to be a narrowing of vision where breadth of vision is sought. Many times the general science course will be found to improve as the *teacher's view is broadened.*

The desired breadth of view does not come from a discussion of general science by chemistry teachers alone; it does not come from physics teachers, nor from biology teachers. When teachers from the various special fields meet in joint session and forget as much as possible they are specialists and when they make an honest endeavor to *learn* something from their fellow teachers in other fields of science, rather than each one trying to convince the others that he has the only thing worth teaching, then and not until then will there be much improvement in our

general science teaching. This is as true of method as of content.

The greatest need of science teachers at the present time is a forum, a club, an association—call it what you will—where science teachers representing different departments of science may meet, expound, discuss, deliberate and learn. There ought to be an organization in each of many local centers whose business it is to consider the pressing questions, the live questions in *general science*. Some state science teachers' associations have already established a *General Science Section*. This is a move in the right direction, but a small local club, meeting several times a year, would be of even greater value. The *Quarterly* will be glad to hear of any clubs or sections which are organized.

JUNIOR HIGH SCHOOLS ARE OFFERING GENERAL SCIENCE COURSES.

General Science is elective in the ninth grade of the junior high school in Adrian, Mich. Two hundred and twenty five minutes are given to it per week. The department is well equipped with apparatus for demonstration and experimental work. The second year of the course was marked by a 20% increase in the number of students taking the course.

Under the direction of the Edward Little High School of Auburn, Maine, is a two year junior high and a three year senior high school. In the first year of the junior high school, general science is a required subject two periods a week. In the second year general science is required three or five periods per week of pupils in the General Course and three periods per week of pupils in the Commercial Course. College preparatory pupils do not take general science in second year of the junior high.

Chelsea, Wakefield, and Wellesley, Massachusetts are introducing general science into their elementary or junior high schools this year.

Providence, R. I. has introduced general science into the seventh and eighth grades.

In the Washington Junior High School of Rochester, N. Y., two 90-minute periods are given per week to general science in the seventh grade. In the eighth grade general science is offered only to pupils in industrial and domestic science courses. General science is a required subject for all pupils in the ninth grade.

In Gary, Indiana, elementary science along the lines of special science has been carried on for several years in grades five to nine.

GENEROUS SOULED SCIENCE TEACHERS

It is encouraging to see what a large per cent. of the science teachers are willing, even eager, to help along a new enterprise which is attempting to fill a real and long felt need. The reception of the *General Science Quarterly* idea in *advance* of the actual appearance of the journal itself has been most gratifying.

If you do not find the kind of help you wish in the pages of this journal during the year, please write to the editor, suggesting the things which you would find most helpful in your work.

While the pages of this journal are open to the discussion of *theories* of teaching general science, the main purpose is to set forth the *best practice* in teaching it. It is often very difficult to apply theories of teaching under actual working conditions. Occasionally some teacher makes a successful application, or by accident stumbles upon a very successful lesson or series of lessons. If he be a generous souled teacher, as most science teachers are, he will share his "discovery" with his fellow teachers. You are invited to contribute an account of some of your successful methods, lessons, etc., and in return to profit by similar contributions made by others.

FREE SCIENCE BOOKLETS AND PERIODICALS.

In addition to the books in the hands of pupils and numerous reference books in the library, much valuable help may be obtained from various commercial booklets and periodicals.

The Lighting Handbook is a booklet of some ninety pages and contains much that is suggestive and useful to high school science teachers. It will be sent free to science teachers on application to Ivanhoe-Regent Works of General Electric Company, Cleveland, O.

Helpful Hints to Housewives, a sixteen page booklet giving directions for using the *Domestic Science Fireless Cookstove,* contains valuable information for general science and domestic science teachers. A folder *Tococo Talks,* Vol. 5, printed by the same company has interesting material in it. These will be sent free upon application to the Toledo Cooker Co., Toledo, Ohio.

Household Physics, No. 21 of the journal *Teaching.* This excellent number has articles on physics in the household, qualifications of high school science teachers, home made apparatus, etc.

28 pages. It will be sent free. Apply to *Editor of Teaching,* State Normal School, Emporia, Kansas.

Kodakery, a beautiful illustrated monthly magazine, contains many articles which are excellent for science lessons. It is a great help to anyone who is interested in photography. The magazine is listed at $.50 a year, but teachers who desire to make use of it in science classes can secure it free of charge. Apply to Eastman Kodak Company, Rochester, N. Y.

Du Pont Magazine. Anyone interested in the use of explosives in peaceful pursuits will find some suggestive and useful information and pictures in this monthly magazine. Apply to E. I. de Pont de Nemours & Company, Wilmington, Del. This same company publishes *Vertical Farming,* a monthly journal of special interest to agricultural schools.

General Science Club of New England

During the school year 1915-16 two General Science Conferences were held at the Normal School, Salem, Massachusetts. These were attended by teachers from five different states.

At the first conference the discussion of the high school problems was led by Prof. Woodhull of Teachers College, Prof. Mann of Carnegie Foundation, and Mr. Orr, Deputy Commissioner of Education. Messrs. Vinal, von Hofe, Jr., Moore and Aldrich gave five minute papers. So animated was the discussion that it was voted to continue it at an afternoon session.

At the second conference, Prof. Kilpatrick of Teachers College gave an adddress on *Project Teaching* and Mr. Sherman and Mr. Lunt of Boston gave practical talks on general science in the elementary school.

As an outcome of these meetings, General Science Club of New England was organized with some thirty-seven charter members. The club draws its membership from the elementary school, the high school and the college, and will attempt to blend these different viewpoints. Dr. Dewey has said, "I do not believe that the problem of successful science will be met until teachers in college and high school exchange experience with those in the elementary school, and all take a mutual interest in one another's work." In some measure this club hopes to help do what Dr. Dewey suggests is needed.

(*Continued on page* 64.)

The membership fee is one dollar per year, and anyone interested in general science is eligible to membership. *General Science Quarterly* is the official organ of the club.

General Science Quarterly and membership in the club may both be secured by special arrangement for one dollar and a half a year.

The following officers were elected for one year:

President, Mr. Walter G. Whitman, State Normal School, Salem.

Vice-President, Mr. Samuel F. Tower, English High School, Boston.

Secretary, Mr. George C. Francis, Centre School, Everett.

Treasurer, Mr. Arthur H. Berry, Classical High School, Providence, R. I.

Three members of the *Executive Committee.*

Mr. William Orr, Deputy Commissioner of Education.

Mr. J. Richard Lunt, English High School, Boston.

Miss Mary E. T. Healey, Sherwin School, Boston.

EVENING TWILIGHT

General Science Quarterly

Vol. I. JANUARY, 1917 No. 2

Project Teaching*

By William H. Kilpatrick, Teachers College,
Columbia University.

There is a difference between the "logical" and "psychological" treatment of any subject. Let us imagine a child so young that he has never seen a dog, and then he sees a dog for the first time. He comes away with a notion (expressed in our words) that a dog is a small white animal of about a certain size. His experience has led him to this notion of what a dog is. We know so much more that it seems wrong to call this a logical formulation; yet relative to the child such it is. The experience while he was going through with it was "psychological" in character, and the conclusion is "logical." In the "logical" then he has summed up his experience with the dog and is prepared to expect certain things of a dog the next time he should meet one.

When the child sees a dog again we will say that it is a large, black, growling dog. The child combining this experience with the preceding; now has the notion that dogs may be black or white, large or small, and kind or cross. He has had two "psychological" experiences and has made two successive "logical" formulations. The second "logical" summed in organized form the two preceding experiences. The first "logical" under the in-

*This is not an article written by Professor Kilpatrick, but a compilation—made by permission—of notes taken by various people who have heard him speak on the subject. We recognize that the account as given is necessarily meager; we believe that it is fairly accurate. In any event, Professor Kilpatrick is not responsible for it in the same sense as if it were the product of his pen.

fluence of the second experience gave way to and was merged in the more inclusive second "logical." As time goes on the boy gets a very complete knowledge of dogs,—a much more inclusive "logical" organization. Finally, if his interest and study of dogs continues, he may sum up the most that science has to offer about dogs. He then has a kind of nth degree "logical," which is the logical of science or logic.

In teaching we too generally take the child at the beginning stage of experience and try to give him the most complete adult formulation. We think that we will save time if we give him the adult formulation right out. This is giving the child predigested knowledge; and predigested knowledge, like predigested food, is not good for growing people. The getting must be largely the result of personal experiences; and if we attempt to give directly the results of logical formulation we fail.

Much of our school work is gone at backwards. We prepare a highly organized course, the product of the adult mind, and thrust it upon the child's immature mind and expect him to profit by it because it is so logical and correct in every respect. All the matter is classified and sub-classified. The pupil goes through this matter in the precise manner in which it is offered. This is not the true method of learning. The things we know that do us the most good were not learned in this way, but in spite of it. Mere familiarity with logical organization need not result in logical grasp or logical thinking. The contrary is even more probable.

Activity is the central notion of experience getting. Is all activity equally worth while educationally? If one person sets up a certain goal to be reached and another strives, the activity of neither party is complete. If an individual sees a thing to be done and then proceeds to do it, and tests himself as to whether he has done it, he has shown a complete activity. In the course of living a project arises to the individual. He feels definitely the need of going ahead with his project. He thinks, plans, and devises. He strives to realize his idea or project by carrying out the mediating steps devised. The result attained tests the accuracy of his thinking and doing. These several successive steps form a complete cycle of activity. It is this complete activity which is most helpful educationally. Whenever an individual starts off on a certain line, and sees for himself what

he is going to do, he is working on a project. The formation of the word gives the clue. A project is something pro-jected, a pro-ject, a line of activity held before one and accepted for execution. Project teaching is teaching by means of projects which the individual thus puts before himself to be done. The aim or purpose of project teaching in science is to get the child to propose to himself things to be done in the science field, and to base the work of instruction upon such projects and the accompanying activity of execution.

In the life of a well developed person we may distinguish four stages of activity:

1. *Physical or bodily movement.* The young baby moves but does not handle things.
2. *Manipulation.* The stage in which the baby handles and fingers things, puts them into his mouth, etc.
3. *Construction and Contriving.* Things are put together or taken apart. Things are made. Thinking is done in connection with doing.
4. *Thinking.* Thinking of a higher order where the interest is the intellectual ordering of thoughts or concepts. Not all reach this stage.

The primary purpose of thinking, biologically considered, is to get out of a difficulty. The most of our thinking perhaps is of this type. We have however acquired a secondary purpose of thinking, namely to satisfy curiosity. It gives us pleasure to think. The primary purpose of hearing was for protection, to learn of approaching danger. Hearing thus is primarily to tell us what to do; but we have developed a secondary purpose of hearing, that is, to hear just because we like to hear, songs, instrumental music, etc. It is this secondary type of thinking which most concerns the scholar and scientific enquirer; tho the forms it takes are the same as of extricative thinking.

Let us consider how a child's projects grow with increasing age. The first time that a child takes a doll she merely holds it and looks at it. This is the end. She has no further desire. When she gets older she notices the dress and wishes it off. She takes off the dress. This is a more complex activity than the first; really two activities, holding the doll, and taking off the dress. She next wishes the dress back on the doll. This adds a third activity. A little later she takes off this dress and puts

on another dress. She took it off purposely to put on another; which shows an added complexity. Later she takes off the dress and puts on a night dress for the doll is to go to bed. Here are steps which are almost what we call *means*. The end is to put the doll to bed. In order to do this she thinks out the means, she must take off the day dress and put on the night dress. When the child is still older she makes a dress. She may after making many dresses lose sight of the *end* (getting a dress for the doll) which she first had in her mind, and become so interested in the *means* (making the dress) that making doll dresses will become the *end*. She may then make a wardrobe for the doll. She may make a dress for herself and follow this by making a dress for somebody else. She may become a professional dressmaker, and use plans furnished by others. The plans which are now a *means* may interest her so much that she will study until she is able to originate plans. She eventually plans plans for other dressmakers. Here is an activity which began very simple and spread out to involve greater interests. The child differentiated and found interest in a small part of the whole project. Projects vary with the age of the person and differentiate as the person gets older. Among these projects will be some that are predominantly intellectual. In all these activities considered above there has been a progressively higher intellectual activity.

Suppose that a boy desires to make a boat. He may find that the boat will not stand up straight in the water. He begins to ask himself questions. He may study keels. A still older boy will go at things more scientifically and study equilibrium. Each individual experience is thus leading the boy to some new project, each involving more and more thinking if it is to prove most educative. Each again is most educative if it awakens the individual to full activity. Full activity implies and involves a true project. The project supplies an aim and directs thinking. Thinking, to be worth while, must be directed by an aim held by the person who is to do the thinking. In proportion as the person holds this aim he will be able to select data intelligently. Thinking unless it works is not worth anything. In proportion as it is possible for a person to do all of this—in that proportion he is getting educated. The aim then to be educative must be held, gripped, by the pupil, not merely by the teacher. If we assign the next ten pages the child seldom gets sufficiently inter-

ested to ask about it when he is on the street or at home. If he is working on a boat project he will prick up his ears when he hears someone mention boats. Furthermore, the child organizes his thinking more completely when he has something central as a motive and guide. The more times you as teachers can get this sort of thing going the more organization will the child get in your classes. It is the child's project that organizes his thinking. He will think more about it than about your project. When the child sees the bearing of anything it will be the better remembered. One is constantly amazed at the things a child will remember if only he be interested in them. Again a child that has worked through a project has in fact a model of action for use when he meets a similar difficulty in life. He says, "I did that, guess I can do this." He has more self-reliance. The child comes to formulation of experience through these steps. Formulation sums all preceding experience for use in the next situation.

In general science this general conception means that the boy will start out with some project which involves either as end or means the use of scientific material. If there is something in physics that is pertinent to his project he will use it. So with chemistry or botany or electricity. Each succeeding project will add more knowledge of science and should lead more surely to a use of scientific method. With these advances under proper guidance should come an increase of the more purely intellectual element. This is, the projects should become more strictly and exclusively scientific, culminating with increase of maturity in scientific specialization.

Some may feel that no place has been left for a development of scientific technique. As I recall my laboratory experience in physics much of the earlier work was learning the technique of careful measuring and weighing. Are we in advocating project teaching leaving this out of account? Precisely no. Each one learns technique best when he sees the use of the refinement. Otherwise he tends to be impatient of it. When as an adult I began to write my first book, my paragraph structure was sadly defective. Under the stress of felt need I learned in one month more of the principles of constructing paragraphs than I had in a dozen preceding years. So it is generally not only with adults but equally with children and youths.

There have been objections made to the project method. Some think that the method is too slow. The thing, however, that we most wish our children to get is an attitude toward science. One project in the realm of science devised and carried through by a boy himself is worth fifty formal laboratory exercises mapped out by the teacher. The whole attitude is changed. The boy is thence forth on the lookout to use his experience and to add to it. Again the project method is said to be too haphazard. I should say that what the boy gets in this way he has and holds; what he gets any other way is haphazard and frequently lasts only until examination time. The real difficulty of our plan is to get fruitful projects started. Here we need experimentation; meanwhile I am quite hopeful. But if a fair trial shows that it is impossible for high school boys and girls to get interested in science projects, then I say put science out of the high school. But this means a fuller knowledge of boys and girls, not merely a degree in science. I hope that the time will come when no one will be allowed to teach physics just because he has studied physics. He must know boys and girls and how their minds and spirits behave.

In the project method, then, the child begins to acquire knowledge through ordinary experience. He must organize the more important results of experience into a strategic point of view by which he will control subsequent experiences in the same region. The test of the success in science teaching by the project method is, as I see it, as follows, the more important last:

Have the pupils traversed a fair amount of the more obvious regions of science?

Have they organized some of the more strategic view points?

Have they some familiarity with available sources of information?

Are they curious about scientific matters, proposing questions, each to himself and to others?

Are they disposed to pursue their enquiries carefully (scientifically) and to carry them through to a successful conclusion?

If "yes" is the answer to these questions, the teaching has been successful.

An Experiment in Eighth Grade Science*

By LEONARD M. PATTON, Master, Edward Everett School, Dorchester, Massachusetts.

Two years ago a Boston high school teacher of science was my neighbor in Milton. We visited together a good deal and much of our talk was about science. This man was and is an enthusiast, and, from time to time, showed me some of the notebooks of his first year high school pupils and told how he was working with them. Later I visited some of his classes to see the boys themselves. The work was so clearly, simply, and interestingly presented that it seemed to me that much of a course like that could well be given to pupils of a lower grade. We talked the matter over. He was willing to give the course a trial in our school if allowed the opportunity. The superintendent was agreeable to the plan and the principal in charge of the high school found two hours a week to give us from his program.

We took an eighth grade in our main building, a class of average ability, numbering about 40, and composed of boys and girls. Owing to conditions, we were obliged to take the two hours a week on Monday afternoons.

This two hour period may be considered objectionable and undoubtedly is not the best division of time, but we could not arrange our school schedule otherwise,—and we were surprised to find the children fresh and alert at the close of a strenuous two hours. This probably was due to the method employed.

The work continued throughout the year with a constantly growing interest and enthusiasm and many of the boys elected in June the high school from which this teacher came, principally for the purpose of continuing under him their science course.

Afterwards, in discussing the ability of the eighth grade pupils as compared with that of the pupils of the first year high school pupils, this teacher said he could see little difference, although he thought the grammar school pupils seemed a little quicker to grasp and hold the subject.

That year's work has confirmed me in the opinion that much high school science, so-called, could be given earlier than it is at the present time and that it is perfectly practicable,—if properly presented.

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*Address before the General Science Club of New England, Nov. 18, 1916.

It has been said that "He who has learned to discriminate between the essentially and relatively important has mastered the whole secret of life," but just so long as individuals differ there is bound to be a difference in opinion as to the essentially and relatively important.

This teacher spent hours over the problems; he read; he visited manufacturing plants; he talked with experts; and then—far from satisfied—he submitted his plan for a year's work.

OUTLINE OF THE COURSE GIVEN*

Project 1. A Study of Fuels used at Home.

I. A Study of Coal (from samples).

1. Transportation of Coal.
   - Where it comes from.
   - How shipped to Boston.
   - How unloaded and stored at the yards.
2. A Study of Soft Coal—color, fracture, lustre, composition, uses, how it burns.
3. A Study of Hard Coal—color, fracture, lustre, composition, uses, how it burns.
4. Kinds of Hard Coal—Franklin, Lackawanna, Lehigh, Shamokin, etc.
5. How to buy coal.
   - Cost per ton, quarter ton and bag.
   - When to buy coal.
   - Assurance of just weight—Study of the Weigher's Certificate.
   - Slate and water in coal.
6. The screening of coal.

SIZE	COST PER TON	USE
PEA		
NUT		
STOVE		
EGG		
FURNACE		

*This outline was prepared by Mr. J. Richard Lunt, of the English High School, Boston.

II. A Study of Wood (similar to I).
III. A Study of Charcoal (similar to I.).
IV. A Study of Coke (similar to I.).

Project 2. My Kitchen Stove.
I. Home study of parts and operations.
II. Drawings to illustrate these parts.
III. How to clean out the stove.

Project 3. How to Kindle a Fire in the Stove.
I. Kindle a coal fire using only paper, wood and coal.
II. Manipulation of the drafts and dampers.
III. How the fuel kindles.
IV. School experiment to illustrate kindling.
Temperatures—using a match, paper, kerosene, small splints, coal, etc.
V. Cause of difficulties encountered.

Project 4. How the Draught Works.
I. Kindle a fire in the stove. With a smoking splint or joss stick, trace the draught from the ash door slide to the smoke pipe.
Course of draught with direct draft damper open.
Course of draught with direct draft damper closed.
II. What causes the draught.
1. Show that air expands when heated.
2. Balance two empty flasks. Heat one to show that cold air is heavier.
3. Circulation apparatus. Box and two lamp chimneys.
III. Application of the principles of circulation to the draught of the stove.

Project 5. How to Make the Fire Burn Fast.
1. Open ash door slide and direct draft damper.
Hold a smoking splint or joss stick before the ash door slide.
2. Observations.
3. Why the fire burns faster.
Air contains oxygen (given if necessary).
A study of oxygen (experiment).

Project 6. How to Check the Fire.
I. Manipulation of slides and dampers.
II. Observations.

III. Experiment. With a piece of wire lower a burning candle into a large jar. Cover the mouth.

Project 7. The Study of a Wood Fire.

I. Observations of a wood fire at home.

1. What are the yellow flames?
   Distill some wood in a test tube.
2. What are the red coals?
3. What are the black coals?
4. How does the wood break up?
5. What is ash?
6. What is smoke?
   Smoking lamp good to show this.

Project 8. The Study of a Coal Fire.

I. Observations of a coal fire at home.
   What are the blue flames?
   Rest similar to wood fire.

Project 9. What becomes of Fuel when it Burns?

I. What remains in the stove after wood is burned?

II. Weigh a small piece of wood. Shave it into pieces. Burn them. Weigh the ash. Find the per cent of ash.

III. What happens to the rest of the wood?
   Ignite a small piece of charcoal. Suspend it in a jar of oxygen, keeping the mouth of the jar closed. Carbon disappears, fire goes out from lack of oxygen, both elements still in the jar.

IV. What is formed in the jar?
   Pour a little lime water in the jar. Pour some into a second jar.
   What must this new gas be composed of?

V. Application of principles.
   What becomes of coal when it burns?
   Coke? Charcoal?
   Blow the breath into a jar of clear lime water.

Project 10. How Heat Travels.

1. How does the heat from the kitchen stove travel to the opposite sides of the room.
   With a smoking splint or joss stick trace the circulation of air from the stove to the corners of the room. Explain.
   Open the broiler door. Hold the cheek near the door.

Can the heat come by convection? Joss stick. Hold a book in front of the cheek. Remove it. Cover part of the cheek with the book. Hold a piece of glass before the cheek. If possible do this experiment before the open fire place.

2. Put the end of the stove poker in the fire.

Feel of it from time to time.

Put an aluminum spoon and an iron or silver spoon of the same size into boiling water. Feel of the ends of the spoons.

Application of the principles of conduction to fireless cooker, refrigerator, wooden handles, woolen clothing, etc.

Project 11. How Illuminating Gas is Made.

I. Grind a few pieces of soft coal to a powder. Put a small quantity of this powder into a test tube. Bend a short glass tube at right angles. Insert the end through a cork stopper. Push the stopper into the mouth of the test tube. Heat the coal with a Bunsen burner.

Ignite the escaping gas.

Note the brown deposit (coal tar).

Break the test tube. Examine the contents.

II. Application to the manufacture of coal gas and coke.

III. Explanation of water gas manufacture.

IV. Illuminating gas sold in Boston. Coal and water gas.

Project 12. Properties of Illuminating Gas.

I. Collect a jar full of gas from the gas pipe by water displacement.

Observe the color. Odor.

Effects from breathing escaping gas.

II. Lower a burning candle into the jar.

Does the candle continue to burn?

Cover the mouth of the jar.

Does the gas burn?

III. Fill a jar about 1-5 full of water. Invert in a basin of water. Displace this water with illuminating gas. Cautiously hold a burning splint above the mouth of the jar.

Dangers from gas explosions. From gas leaks.

Project 13. Composition of Illuminating Gas.

I. Hold a porcelain dish in the yellow flame of the Bunsen burner.

What collects on the dish?

II. Bring a large battery jar quickly down over the blue flame of the Bunsen burner.

What collects on the sides of the jar?

How was this substance formed?

III. What three elements have you found?

IV. Products of combustion from illuminating gas.

Repeat showing that water is given off.

Burn a jar of illuminating gas.

Add a little lime water.

How was this CO_2 formed?

Project 14. How to Read a Gas Meter.

I. Construction of the gas meter.

II. The dial of a gas meter.

III. Reading practice from blackboard.

IV. Read the gas meter at home.

Project 15. The Cost of Illuminating Gas.

I. How it is sold.

II. Cost per 1000 cubic feet.

III. Number of cubic feet for one cent.

IV. Number of cubic feet for 25 cents.

V. The quarter meter.

VI. How to estimate gas bills.

Project 16. Comparative Study of the Blue and Yellow Flames.

I. Study of the blue flame.

II. Study of the yellow flame.

III. Which flame gives the more intense heat?

Cut two pieces of glass tubing 8 inches long. Support the ends at the same height. Use two Bunsen burners, one with a yellow flame, the other with a blue flame.

At the same time place both burners directly under the centers of the glass tubing, one burner under one glass tube, the other under the other glass tube.

Which tube bends first?

Why should we use the blue flame in the gas range?

Project 17. Boiling Potatoes with Illuminating Gas.

I. Use two small gas plates. Place two small kettles of the same size, one on each plate. Fill each kettle about ¾ full of water. Light the gas. When the water in both

kettles begin to boil, turn down the gas flame under one kettle so that the water boils slowly, under the other kettle turn the gas flame up to its full height so that the water boils violently.

At the same time drop 3 small potatoes into one kettle and the same number into the other kettle. Try to have the potatoes as near the same size as possible.

II. Which potatoes will cook quicker?

Examine the potatoes with a fork until they are soft.

III. Why do the potatoes cook as quickly in the kettle when the water boils slowly?

With a thermometer take the temperature of the water in each kettle.

In which kettle is more water evaporated?

What becomes of the extra heat?

Which kettle uses the more gas. (if possible estimate with a sweep hand minute observation meter the difference in cost).

IV. Application of these principles to home cooking.

Project 18. A Study of Open Gas Burners.

I. Types of open burners.

Bray, Empire, lava tip, jumbo, aluminum tip.

II. How to use the open burner.

Gas blowing, gas normal.

III. Cost per hour of open burners.

Estimate with watch and the 2 cubic foot hand of the gas meter at home the cost per hour of an open burner.

Project 19. A Study of the Welsbach Burner.

I. The Junior Welsbach.

Parts of the Junior Welsbach.

II. Set up each part separately. Ignite the gas to show the part each plays.

a. nipple.
b. cap.
c. burner shaft.
d. mantle.
e. globe.
f. shade.

III. Cost per hour (home estimate).

Project 20. The Kerosene Lamp.

Project 21. Planting a bacteria garden from dust.

Project 22. Planting a bacteria garden from a toothbrush.

Project 23. Planting a bacteria garden by letting a fly walk across the agar.
Project 24. A Study of Germicides.
Project 25. How Heat Affects Bacteria.
Project 26. The Dark Tenement House Problems.
Project 27. A Study of Molds.
Project 28. A Study of Yeast.

In these lessons no information came from the teacher. The boys and the girls reasoned from their own experience and observation.

No text-books were used, though the children were at liberty to consult books or persons if they wished.

Note-books were kept and carefully inspected to see that the pupils were getting the work as it was developed.

These note-books were so highly prized that it was difficult to secure one at the close of the course as an office record of the work.

The word "project" in this course meant a problem and its solution by the children.

Progress was slow at times, but we believe it was time well spent in teaching the children two very essential things; how to think and reason well.

At the end of the year we had a class of interested, wide awake, *thinking* boys and girls. All that they had learned had come from themselves, drawn out, to be sure, by skillful questioning, but their own experience and observation summed up, correlated and systematized.

The question may have arisen in your minds, "Why *this* choice of material?" The answer is: At that time, such a course for our particular district seemed advisable and practical. It may not in its entirety be adapted to another district nor our own two years in succession.

One of the first requisites of a good course of study in science is a close relation of its subject matter to the life and experience of the child; a dealing with the things around and about him; in other words his work must be hitched up largely to his environment.

This, our science teacher tried to do, and he seemed fairly successful, but at this point comes a difficulty. All teachers aren't adapted to science teaching; I will go farther and say that but a comparatively few can teach this subject satisfactorily.

No matter how excellent the course, or method,—in the last analysis—real success depends upon the personality of the teacher. Given the best course of study in the world and an approved method of presentation, unless the teacher is sympathetic, open-minded, willing, enthusiastic, progressive, her work will amount to little. I am convinced that before we get good results in science we must have a trained corps of science teachers, with the work properly outlined and systematically supervised.

The great trouble with our science teaching is not primarily the course, nor the method, but the lack of this trained corps of able teachers. We have a good course of study for the Boston Elementary Schools, prepared by a capable committee of men and women, but in general it is slighted and neglected all through the city, not purposely nor wilfully perhaps, but because it requires thought and preparation in foreign fields; it requires study; it is a disturbing thing because it is always so different; unexpected questions are continually coming up; it opens so many windows in the child's mind that the teacher is herself bewildered.

An upper grade teacher came to me recently, and said, "My children are driving me wild; they come to me about everything and I don't seem to know anything." That is what so many teachers dread in this science work. It embraces so much, requires so much thought and preparation, is always so new, and exposes so much of ignorance that they hesitate to enter into the conflict. As they grow older they will learn it is no disgrace not to know all things.

What can we do about it? Is there a remedy?

The following suggestions are offered in the hope that some of them may be worthy your consideration.

1. Wherever departmental teaching is feasible, have some one teacher take over the science work. It is necessary, of course, to select wisely this teacher, especially when the course is being introduced.

2. To insure success, the head of the school system must be in sympathy with the movement. In a large city system like Boston not only the head but the co-workers all along the line, must be in sympathy. In the average town the co-operation of superintendent and principals is enough. In the rural sections, where districts have not been consolidated, the problem is difficult to

solve, although the need here is greater, probably, than anywhere else.

3. Some definite financial support must be given for equipment. In the eighth grade the apparatus is simple but a small fund should be available.

4. Opportunity should be given for field work. The kind of work will vary with the opportunity, but the right teacher may be depended upon to do her part if she has liberty of action.

5. Talks and lectures by science teachers of standing and experience to groups interested in the subject, will often bear fruit, bringing many into sympathy with science teaching if not into the science teaching group.

6. There should be more science teacher training in the normal schools and colleges so that when the demand comes there will be well prepared teachers to take up the work.

7. In cities and towns, and in compact districts, there should be a Permanent Council of Local Teachers who are interested in science, whose duty shall be to prepare the course of study and supervise the work.

NOTE: For a year or more a council of Boston Normal, High, and Grammar School teachers has been working on a science course for the junior high school,—and another council is at work revising the course for the grades.

These teachers are endeavoring to eliminate all but the essentially important things from their outlines and they are having a hard time.

The work of the Junior High School Council is especially difficult, dealing, as it does, with a comparatively new phase of school organization, and attempting a three years' course for seventh, eighth and ninth grades that shall be continuous, constructive, and related science work.

But there are the problems facing all of us. Every school and district has its own work to do. No two will have the same problem or the same work, and if they did they would not go at it in the same way. We have our little bit to do here in Boston and we are doing it with pleasure. We are experimenting as you are, and talking and reading; attending lectures and meetings like this; observing, learning. Out of it all is bound to come some good and we are glad—and ought to be glad—that we have been able to do our small part.

The Selection and Arrangement of Material in a General Science Course*

Arthur C. Johnson, Jr., Englewood, N. J. High School.

To many of us within the past few years has come the need for thoughts on the subject of general science; to each has come the need for orientation with respect to the presentation of material that the pupils under our care may secure the greatest benefit with the least outlay of energy on their part and ours.

The aims for the study of general science have had various formulations. Summed up they fall under two classifications:

I. As tool material for those who later will go on in the study of the specific sciences, or some of them here grouped together.

II. As material to function in their activities beyond school life, either for those who are eliminated early from school, or who study no other science during their course.

These two aims involve somewhat of a contradiction. In the first there is a shifting of responsibility to the other courses to be pursued; our function being merely to co-ordinate and give the elements that will underlie and unite the individual sciences. Some authors go so far as to emphasize this aim. To any one who has studied the problem of elimination, or who realizes the number who graduate with a minimum of science, the second aim will appeal the stronger, and to teachers it can rightly be the only aim, for the two are not incompatible. There is the broader field and to them can come the joy of an actual accomplishment. This means and it is generally accepted that the subject matter of general science must not be differentiated as physics, chemistry, biology or what not, but must avoid these terms and become as its name implies simply science. And here is where most of the text-book authors fail. Specialists in one science usually, even though they attempt non-partisanship, their books are permeated with the attitude of their specialty, and we get the atmosphere of physics as physics, or chemistry as chemistry, even though the names be omitted. Teachers can see it and

*Address before the Elementary Science Section of the New Jersey State Science Teachers Association, at Hackensack, Nov., 1916.

the pupils feel it. Furthermore most of the texts are permeated with the scholastic attitude and are not in themselves complete.

Let us assume that the aim is to prepare pupils for life, instead of continuing the study of science. After all, why should we shift the responsibility; it is a sign of weakness. What constitutes this preparation for life? What concrete facts have we to guide us? And what is this life for which they are to be prepared? The problem becomes what shall we give and how shall we give it? Our method historically has been to determine what we as pedagogues thought necessary, giving it as we, as adults and theorists, thought it ought to be given and with no sound theory but traditions to back us up. It is as though we worked from a program through the conditions—children—to a conceived social need and blindly thought that we met that need. We are just beginning to understand that the social need is our aim and should form our basis of orientation and that our limiting conditions are the children. It is through these that we must determine the program to meet that need. Today we are only beginning to recognize this social need and are but beginning the study of the conditions that limit us, but so far as the science program of the immediate past has been, we are almost safe in saying that it has been void of any functioning significance. This is rapidly changing. We now have several functioning branches: household physics, domestic chemistry, agricultural biology, et cetera. Go back to the early days of science teaching in the high school, or its forerunner, the academy: look over the texts in use say fifty years ago and although they were cumbersome tomes and prosy in the main, they did have a large amount of practical usable material: books almost usable today and far more satisfactory to the pupil than the texts of fifteen years ago.

We are now in a science rennaissance. The early writers recognized that there was a twofold purpose in the teaching of science, a tool side and an appreciative side and for this latter they did not hesitate to bring in play material, soft pedagogy perhaps, balancing it with the hardest kind of material development on the tool side. And they were partly right. There is and should be a play side to any subject and at the risk of being misunderstood, I will say that there is a place for soft pedagogy in the field of general science, but it means the hardest kind of pedagogy for the teacher and only play for the pupils if they gain an appreciative attitude toward

science and realize that it is not so great and deep and prosy and difficult, but merely the application of every-day common sense to the phenomena of their surroundings. As one author puts it,—"Some uncommon ways of looking at common things." They have a fundamental liking for science. Have you seen a boy spend a great big fifteen cents on a copy of "Popular Mechanics" or "Popular Science Monthly"? And one of the prominent teachers in our field is even now showing us that there is teaching and teachable material in these magazines, or one of them. The text-book for general science has yet to be written and it must contain much material that will stick in the minds of the pupil readers in spite of them, because of the play material it furnishes. Some writers have approached perilously near, but all have seemed afraid to really make a point of it. Such a book will produce results beyond our present dreams.

One other point in which much error of thought exists: we work in terms of present need, of present environment. We should and must work in terms of present capacities but to satisfy a future, adult need in a world environment. Education is to train for adulthood and adult functioning as a member of society. In the selection of material we must bear these two points in mind. Choose that that will be of use to the pupil as an adult and select and arrange it so that its acquisition may be made now in immaturity. We must create a present desire through interest and this can only be done through present activities; one great part of which is play and informational amusement.

What material is within our field that the adult needs and that the child can comprehend and acquire? What are the big things within this field that every one should know, man as well as woman; in Maine as in California; poor as wealthy?

As adults, given a situation, how do they go about securing a solution of the problems of that situation? These situations do not come singly as a rule. A home builder is called upon to determine the heating plant he will install. If he builds carefully he will investigate all forms, look to the literature of all types, listen to arguments for and against each. Finally he forms a judgment and orders one form installed. He buys an automobile or a motor boat and finds that it is not simply an engine, but a multitude of mechanical devices and he sets about acquiring an operating knowledge of each. A manufacturer is called upon to

install power and he compares, steam, water and electric; not its source and efficiency alone, but its utilization through the ramifications of his plant. As a member of his Town Board he is called to vote upon the installation or rejuvenation of the water system, or sewage disposal or lighting system and an enormous number of considerations enter. In every case the main problem is a complex one, made up of innumerable smaller ones.

It is the recognition of this that is bringing to us to-day a new method so-called,—the project method. This is a misnomer. It is not a method but an aim. But through it we are arriving at the threshold of a new science, a real, living, functioning, training something that makes of science a thing apart from many of the subjects of the curriculum. Already the other subjects recognize its value and are adopting or forcing it into their scheme of things.

We are falling into one misconception. We do not clearly define our method of procedure. We do not clearly see the steps involved in the logical development of science material. For general science the project must be the big inclusive thing about which information is desired or needed and includes many sub-divisions or topics. Heating is a project and the various methods of heat installation, costs, weather, conditions, fuel supply, et cetera, topics. Power is a project and the horse-treadmill, simple machines, hydrokinetics, steam boiler, Corliss engine, electric motor, et cetera, are topics. Water supply is a project and land conformation, soil stratification, rainfall, dams, filtration, water pollution and purification, all hydrostatics are topics. And again under the topic are sub-divisions, the local problems through which directly the knowledge of the other larger groupings will be acquired. With power as a project, the gas engine becomes a topic and valving, the carburetor and gearing are illustrations of problems under it. The method of handling this material is best developed by what is termed at present the project method. The situation is secured in the form of several problems to be solved individually. These collectively furnish the necessary information and technique concerning the topic and these topics in turn collectively round out our understanding and appreciation of the larger situation.

So far as actual class room teaching is concerned this all becomes a mere quibble over words. The correct class room procedure is as it has been, but the point involved concerns itself with the organization of material rather than the handling of it after it is

organized. My message is to those who have this side of the situation and only to the teachers in so far as they can modify existing conditions to conform to the ideas here contained. And a little thought will show many ways in which this can be accomplished.

If the point of view that I would convey has been secured, the value of such an organization lies in the coördination of the sciences in the development of the project. There is no need to even think physics, chemistry, physiography or biology: they present themselves naturally and unostentatiously as aids in the analysis and classification of the project.

But we must get away from the idea of traditionally logical sequence. We must study a subject only when the need for its study becomes apparent in the solution of the problem in hand. Pumps are studied when it is necessary to elevate water: oxidation is studied when it is necessary to secure information as to the action of the atmosphere on substances. Our projects select themselves, but we must so arrange them that the topical problems under them form a sequence that is developmental, contiguous and continuous in character.

To be a bit more specific I believe that all the problems we have or need to consider in general science come under one of the following as projects:

The earth in its relation to man.
The atmosphere.
Water.
The human body.
Health and its preservation.
Food.
Clothing.
The home.
Heat.
Light.
Power.
Electricity.
Means of communication.
Plants in their relation to man.
Animals in their relation to man.
Recreation.
The earth's place in the universe.

All of man's activities and interests are concerned in problems under one of these major groupings. I am not yet entirely certain in my own mind as to the natural sequence in some of these; yet it is evident what the trend must be.

The child before coming to us has considered only geography of the so-called sciences and that usually in an unscientific manner. There are those who say that geography is not a fundamental subject, but nevertheless the pupil does have a certain knowledge of the world and world forms and this blends into our science of physiography. If we are to go from the known to the related unknown, our best approach is through the data of physiography working into physiology and hygiene and to the advanced sciences, advanced because foreign to the child in his school experience. Let these latter sciences enter the function whenever and wherever the need arises to clear up or amplify the work in hand and let them become increasingly predominant as the method of approach and attack becomes familiar.

To sum up, I would classify all the material to be presented in a course in general science under several great groupings that represent the interests and activities of the adult in society, making the approach as he would make it and taking up a given problem only when the need for it has arisen in the progress of making clear the larger topic. I would place first those interests that most nearly relate to the previous training and approach of the pupil. And I would not hesitate to make easy his approach to new material by the use of devices that require no deep thought in acquisition or effort in retention.

General Science Bulletin*

(*Continued from page* 46.)

MASSACHUSETTS COMMITTEE.

Psychological Factors Affecting Method, Material and Organization.

It is assumed that pupils over 12 and under 16 are possessed with large potential curiosity about natural phenomena and physical forces and their applications to industry. This interest, while

*This is a preliminary draft and not the final report of this Committee.

often dormant, can be easily aroused and directed when the subjects for study are presented to the child with due regard to his limitation and capacity.

Children of this age are developing initiative and self-activity along mental lines and respond quickly to suggestions by the teacher. When formal tasks are imposed, which do not appeal to the pupil's interest the effect is often to kill interest and enthusiasm.

Observation by teachers of general science warrant the conclusion that among other intellectual aspirations of pupils of this age, the desire to control and direct natural forces is strong. Others possess a keen interest in knowledge, in itself.

Children of this age also possess much unorganized, miscellaneous knowledge of nature gained from reading and experience. The kind and amount of such material differs greatly in individual children because they have had little or no formal instruction in science in the lower grades. Their ideas of nature are crude. There is much mis-information and little capacity to discriminate between reliable and merely sensational statements.

When a given unit is undertaken the teacher should ascertain at the outset what the children know or think about the subject and also what are the questions uppermost in their minds regarding the topic under consideration.

It is desirable that the pupil should become consciously or unconsciously aware of some perplexity or problem he wishes to define or identify and become eager to seek the solution by means of various crude hypotheses which he tests by observation or experience until the conclusion is reached. If the child's desire to solve a problem can be aroused then he works consciously to satisfy a personal need. This need may rise in the ordinary course of experience or may be the result of the influence of the teacher, who stimulates the pupil's curiosity through some exercise, reading or lecture, and arouses a desire for further knowledge. Ideally, in all work in general science, the pupil should "Want to know."

While due consideration should be paid to individual interests it is also possible to select units, projects and subjects which are of common interest to all members of a class or section.

The teacher should keep in mind the difference in interests of boys as compared with girls. Boys are interested in great industries, in out door activities, in games, sports, and in general, in

affairs belonging to the world of man. The predominant interests of girls are in the home and in the activities within the woman's sphere. Distinctions of this kind must not be taken too literally as boys and girls have many common interests and consequently can frequently co-operate in a common program in general science.

Social Factors.

The pupil today lives in an environment distinctly different from that of his ancestors of three or even one generation ago. A comparison of the extent to which a knowledge of nature and the use of natural forces was prevalent in the early decades of the 19th century with the scientific knowledge and applications of science that obtain today cannot but impress one with the need of some understanding of science and of scientific methods as a basis for appreciation of a very large part of his daily experience.

Man's knowledge of the physical universe has so increased that the possibilities in the way of delightful and satisfying study of natural phenomena and processes are practically unlimited. It may in truth be said that one who has not acquired the habit of observing nature at first hand, and who has not developed an intelligent and broad interest in natural phenomena and in science is virtually deaf and blind; in fact, insensible to large and important areas of experience.

Compare, for example, the satisfaction that a John Muir, an Edison, a Burroughs, or a Gray finds in the nature in which they are particularly interested with that of a person who has never learned to appreciate the rich treasures of nature.

It is eminently fitting that the schools should lead the boy and girl into this fairyland of science, and enable them to see understandingly the wonders thereof.

When one considers the great number of popular articles dealing with nature in magazines and in newspapers, much material in technical journals, numerous allusions in literature, many books and pamphlets on various aspects of scientific study, it is clear that unless one at the same time acquires both an interest and an ability to read intelligently such literature, he is debarred from fruitful and satisfying fields of study.

Bacon's maxim: "Studies serve also for delight" finds ample justification today in the opportunities afforded for mental activity in the realm of science.

On the side of civic education, the dweller in any community, large or small, in order to intelligently understand the interests of that community in protecting and safeguarding its material side, must have interest in and comprehension of the value of expert knowledge of natural phenomena, and of the application of science in the service of man; thus only can he appreciate the importance of adequate fire protection; of a sufficient and pure water supply; means of combatting insect pests, plagues, and disease; the necessity of quarantine under certain conditions; the value of advance information as to weather changes; and the thousand and one appliances whereby human health, safety and comfort are promoted.

Such knowledge should foster appreciation of the value of the expert in public service enterprises where scientific knowledge and application play so large a part. This knowledge on the part of the citizen should so promote a civic intelligence and spirit as will ensure the appointment of capable men instead of politicians for important posts and responsibilities.

A knowledge of scientific facts and principles relating to the care of the human body, viz.—good food, proper ventilation, good sanitation, including protection against insect and other sources of contagion and the control of conditions that threaten health—is essential to a better physical status on the part of the individual and the community.

Much of the scientific knowledge gained in the course in general science will, as a by-product at least, give valuable information to the pupil as to the lines along which his interests lie and in which he is most likely to succeed. It may happen also at times that the knowledge gained and the skill acquired may actually be applicable in the calling on which the pupil enters.

Mental satisfaction and pleasure are enhanced when there exists in any community a large fund of common interest in scientific subjects, since the conversation, discussions, and public conferences in such a community possess elements of interest entirely lacking when there are not such intellectual resources.

On all these grounds, then, a course in general science constitutes an important part in the program of the education of the boy and girl in the early stages of secondary education.

Selection of Units

A wide range of units, involving projects, demonstrations, experiments and topics, should be available for use in general science classes. There should be at command much more material than can possibly be used in the time allotted for general science. When the teacher has once grasped the method of gaining material and organizing it, abundant resources will be found.

Out of this abundance the teacher in co-operation with the pupils should select progressively the units for the work of the year. All the content should not be determined or selected at the outset. As the work proceeds the interests of pupils and teachers will suggest new fields of study fruitful in material.

Certain general principles should be kept in mind in selecting units.

1. The problems and topics should appeal to the pupils and be within their capacity to master without undue effort or excessive expenditure of time.

2. Material related to knowledge already at command or connected with actual desire to accomplish is also desirable.

3. As regards the element of interest the skillful teacher will select those factors or aspects most likely to appeal to the pupil. By a natural law of the mind such appeal is best made along the line of previous experience or a knowledge already possessed. The following factors contribute to interest:—

(A). Practical value, including utility, for the individual, for the family, and for the community. Such values appeal strongly. While the purpose of general science is not primarily utilitarian, the teacher may well take advantage of motives based on utility. A pupil making an article of value or engaged in a productive process often gains distinctly cultural results.

(B). Unusual Conditions. Another element that promotes interest is found in the using of projects connected with some exceptional condition, as,—a new water supply; the efforts to control an epidemic; a great fire as indicating need of greater fire protection.

Subjects of this nature that are more or less a matter for public consideration and discussion will be found most valuable and fruitful in suggestion.

4. The elements of any general unit should not be over abstract in character. Generalizations, in themselves, do not appeal

to pupils of this age. In fact, they cannot, in many cases, be grasped in any thorough fashion. At the beginning, the material should be particular and concrete, consisting of individual cases and incidents. After some material of this kind has been mastered the teacher may then lead pupils to establish generalizations, while, in turn, other particular projects and topics may be based upon such generalizations. Once generalizations have been established the way is open for extensive reading.

5. The unit should be rich in content and fertile in suggestion. It should induct the pupil into broad and extensive fields of study and observation. Otherwise his attention becomes diverted, diffused and distracted by meagre and, consequently, disappointing enterprises.

6. The unit in a general science course should be mainly related to local environment, natural or industrial. Such material can be more easily utilized with less expenditure of effort than when one seeks units in a remote field. General science in a rural high school, should include phenomena relating to plants, animals, earth formations, weather changes and household devices. In a city high school the units should relate to extensive and more highly organized applications of science, because these are found in the city environment. Great industrial centers afford units dealing with the use of natural forces in transforming material, in form or in substance.

Organization of Material.

A teacher accustomed to assign lessons from a text book is very naturally bewildered and at a loss when such ready made material is not available and he must select the content of the study from many sources, including local phenomena and a wide range of books, magazines, newspapers, catalogues and reports. When one considers, in addition, that the pupil is to gain his information in various ways, namely; experiment, observation, demonstration and reading, it is inevitable that unless utter confusion is to follow, the teacher must be actuated by certain definite principles of selection and organization.

General science material should be organized as a number of general units. Each unit should be selected in accord with the aims of general science and should appeal to the pupil as being distinctly worth while in order that he may approach it with interest and purpose. When a pupil once engages in a piece of work

which he really desires to accomplish, results are much more substantial than when he is doing something simply because ordered or required by the teacher.

Each unit should consist of a large central theme involving problems or projects, of various kind, so related to the experience and interests of the pupils as to make him feel that their solution is worth while. These problems should of themselves strongly impress upon the pupil the fact that the science of the school and the science of the "outside world" are identical. He should feel that he is learning why things are as he finds them and that scientific knowledge has preceded most of our modern scientific achievement and invention.

The following definitions and terms used in connection with the organization of material are proposed:—

(A). *General Unit.* A main or central theme to be developed by means of undertakings, studies, exercises, by a class as a whole, by the teacher, by individuals or by groups as it seems advisable. Each of these separate undertakings while constituting a definite problem in itself and with a unity of its own will constitute a body of organized material more or less closely inter-related. No definite allotment of time should be made for the completion of the work on a general unit though it may be stated that in general not less than ten nor more than twenty-five class exercises should be devoted to any one unit. The undertakings comprised in a unit include projects, experiments, demonstrations and topics.

(B). *Project.* A project is an undertaking of comparatively limited scope in which a pupil or a group of pupils or an entire class under the direction of a teacher do some definite work in actually making something or in observing or interpreting some phenomena or process included usually in a general unit. (The motive actuating a pupil in working on a project should be based upon definite need or desire. The pupil should seek to achieve an aim of his own motion with self activity dominating in the undertaking). The way in which projects may be performed varies widely and in assigning projects regard should be had to the capacity and interest of the pupil and to the lines of effort and the kind of work which he could follow to the best advantage. Projects are of two kinds:

1. *Construction Projects*: A construction project is one which calls for manual execution either in making a device or machine,

in assembling its parts, in operating such devices or machines or making the same article, or carrying out some processes as for example: making apparatus for wireless telegraph; the pin hole camera; taking photographs with a pin hole camera or regular camera; making a loaf of bread and observing the changes in the process; taking apart a sewing machine and assembling the several parts; taking apart and putting together a camera.

2. *Interpretation Projects*: In performing such a project the pupil observes and interprets some phenomena visible and concrete. He collects information regarding such phenomena by experiment, direct observation, reading or other means which enable him to interpret or explain the object of his study. The pupil should do some reasoning and should gain additional information regarding the phenomena as a result of this reasoning process. Among such interpretation projects may be noted the study of pieces of apparatus such as: telescope; microscope; stereopticon; moving picture apparatus; balances, magnets; mechanical toys; action of yeast; action of baking powder; in these projects the problem in the mind of the pupil grows out of some concrete situation in the field of his observation and experience. Only a small amount of experimental work and that principally for reasons of illustration is needed. Most of the material is gained by reading and observation or presented by the teacher in the form of a demonstration. The pupil in performing such a project should read and otherwise seek answers to particular questions in which his interest has been roused as a result of concrete observation and experience.

(C) *Demonstrations*: A demonstration is an exercise performed before the class or a group to make clear some fact or principle that has been made in working out a project either of construction or interpretation.

Demonstrations are also employed to arouse interest in some particular subject either prior to undertaking a project in that particular field or during the progress of it, as for example: in connection with the study of fire dangers to show the combustible nature of celluloid articles as combs, toys, etc. and the result of bringing such articles near a bare flame or in contact with hot metals.

Demonstrations should, as a rule, be performed by the instructor, but at times the pupil can perform them alone or under the direction and with the assistance of the instructor.

(D) *Laboratory experiments or exercises.* By exercises or experiments is meant a definite piece of work, preferably performed by the pupil for the purpose of establishing some principle or truth or to secure an answer to some problem encountered in a general unit or project or to introduce some unit or project. These experiments or exercises may be performed at home in some cases and in the school laboratory in other instances.

It is obvious that when a pupil is to perform an exercise or experiment without supervision by the teacher he should proceed in accordance with careful directions and with a very definite idea of the object of the experiment.

Laboratory work in a large sense includes observation and recording of data regarding natural phenomena in which the pupil gains or applies knowledge.

(E) *Topics.* A topic calls for the gathering of material by a pupil, a group of pupils or an entire class bearing upon some particular subject. Such material is found in text-books, in popular magazines, newspapers, scientific publications, periodicals, government reports, trade catalogues. The study of a topic should be so directed by the teacher that the reading shall be along definite lines in seeking answers to specific questions and not desultory in character. The reading should be consecutive and should result in substantial understanding of the topic studied.

Topics as a rule deal with subjects of too large and complex a character to be limited to the direct observation or experience of the pupil. Constant reference usually should be made to the scientific principles involved and the pupils should be directed to read along lines suggested by the study of concrete cases. From time to time experiments can be made by the teacher to make clear some principle or process that otherwise might not be secured. As examples of topics there may be cited the following: water supply systems; street car systems; local telephone systems; eclipses of moon or sun; phases of the moon; hot and cold water supply in the home; combustion in the locomotive; concrete construction; local drainage, including sewage; fertilizing for crops; ice age in New England; work of Burbank; story of Pasteur and bacteriology; invention of the steam engine. Local illustrations should be used in every case to give zest and interest to the reading. If the reading gets far away from the experience of the pupil there is likely to be a loss of interest and of clear understanding of the material read.

When these units and projects are wisely selected and well organized the pupil should find something in each which arouses his genuine interest and which challenges his best efforts. While at times the several problems on which the class may be engaged in a given unit may seem to be unrelated, at the close when the results are combined the relation of each part of the main unit should be clearly seen.

While each project or problem in a given unit should be complete in itself, cumulative effect is produced by grouping together a number of projects belonging in the same field of natural phenomena or process. Unless there is some such relationship the result will be a number of isolated and comparatively limited projects and undertakings whereby a pupil is not led to group the knowledge and experience given under any general heads. The result is frequently a dissipation of interest and distraction of attention. General science should abound in effects, phenomena and processes likely to appeal to the interest of the pupil and to be within range of his comprehension.

There are given herewith certain suggestions regarding units and projects, demonstrations, laboratory exercises and topics in each unit. Not in any sense is this to be used as a syllabus, but only as indicating the fields of study open to pupils in general science.

I. *HEAT IN THE HOME.* (General Unit).

(a) How do we produce heat? (Project).

1. *Gas Stoves*:

How should the stove be adjusted and lighted?

Compare with Bunsen burner, plumbers' torch, steam automobile burners, some alcohol lamps, camp stoves, Welsbach lights, etc.

How much does it cost to operate the stove?

Can you measure the heat obtained from it?

How may it be run most economically?

How is gas produced?

2. *Oil Stoves*:

What different kinds are there? What are the good and bad points of each?

How much does it cost to cook or heat with them as compared with gas stoves?

How do they affect the air in a room?
What is "oil"?

3. *Coal Stoves*:
What make of range is best?
What is the best coal stove for heating purposes only?
How does the cost of operation compare with gas?
What is coal?
What size is best to buy?
What is the best way to buy coal?
Why do we use wood and charcoal in starting the fire?

4. *Fire Places*:
Are they good heaters?
What fuels are used?
When and where were fire places first used?

5. *Furnaces*:
How do they heat a house?
What are their good and bad qualities?

6. *Steam Heaters*:
How do they heat a house?
What are their good and bad qualities?
What is the use of the pressure gauge?
What is the diaphragm?
Why is the water glass used?
What is the purpose of the safety valve?
How does it work?
How is it that the air valves let out the air but prevent the steam from escaping?
Steam enters the radiator at a temperature of 212° F. Water leaves the radiator at a temperature of 212° F. Where does the heat come from that heats the room?

7. *Hot Water Heaters*:
How do they heat the house?
What are their good and bad qualities?
Which kind of heater would you select?

(b) How do we regulate the heat? (Project).

1. *Dampers.*

How are they used to regulate the heat—in a stove; in a furnace? (Why are there no dampers in a gas stove?)

How are they automatically changed on a steam heater?

2. *Thermostats.*

How do they work?

Are they reliable?

Are there any disadvantages?

(c) How is heat distributed?

1. *Registers.*

Should they be placed in the wall or the floor?

Why doesn't the air come up through all registers equally?

Can this unequal distribution be remedied?

What makes the air come up at all?

2. *Radiators.*

Why are they called radiators?

Where should they be placed?

Does the nature of the surface or the color of the paint affect the heating quality?

(d) How is heat lost?

1. *Hot Water Tank.*

Do we get the hot water from a tank "for nothing"?

Is it better to have it connected to a stove, house heater, or special gas heater?

How does the water get heated?

How do the materials used affect its efficiency?

Should it be connected directly to the city water supply?

2. *Flue Gases*:

How much heat goes "up the chimney"?

Is there any way of preventing it?

Why is a furnace a wasteful contrivance?

(e) How can we save heat?

1. *Fireless cookers*:

How are they made?

What material is best for packing the walls?

How can the efficiency of the cooker be tested?

Has it any advantages besides saving heat?
Can it be used for anything besides cooking?

2. *"Thermos" Bottles*:
How do they differ from fireless cookers?
Are they more or less efficient?
Are they worth while in the ordinary home?

3. *Burning Ashes*:
Is it a good plan to buy preparations to mix with ashes that they may be burned again?

4. *Covering Pipes*:
With what are steam pipes covered?
How is heat saved by the covering?
Why are water pipes sometimes similarly covered?
Why aren't furnace pipes covered in the same way?

5. *Stove Pipe Heaters, etc.*
Are the heaters which are attached to the stove pipe of the range valuable?
Do we get more heat from these than from the stove pipe directly?
Do heaters sometimes placed on gas lights really save heat?

(f). How can we get rid of heat?

1. *Refrigerators*:
What material is best for the interior?
Where should the ice be placed?
Would a refrigerator which kept the ice from melting be ideal?

2. *Ice Cream Freezers*:
How is the cream frozen?
Why is salt used?
How low a temperature can be obtained with such a mixture?
Could any other be used?
What is the use of the dasher?
Why does the cream sometimes poison us?

3. *Ice houses*:
Why is sawdust used?

4. *Cold Storage Plants*:

(g) Chafing dish fuels.

1. *Alcohols*:

What is the difference between grain alcohol, wood alcohol and denatured alcohol?

How can you tell them apart?

How can you tell by test which one gives the most heat?

Is the one which gives the most heat the best one to purchase?

2. *"Canned heat"*:

How do the solid preparations compare with the alcohols in efficiency, cost, etc.?

Would it pay to buy them?

(h) Too much heat.

1. *Fires.*

How do rubbish heaps tend to cause fires?

Houses have been set on fire by closing registers. How could this happen?

What is "spontaneous combustion"?

How do mice sometimes start fires?

Are there any other common ways in which fires are started?

2. *Fire Extinguishers*:

What different kinds are there?

Are they effective?

What kind should be kept in the house?

How does water put out a fire?

What should be done when a person's clothing gets on fire?

3. *Burns*:

How should burns of various kinds be treated?

Why does steam cause a more painful burn than a hot stove?

Note:—The foregoing questions under each head indicate lines of investigation. The pupils will doubtless suggest many more. While the teacher must expect some of these suggestions to lead into other and remote fields, and be liberal in considering such, he is under obligation to use good judgment as to the proper limit to such excursions into by-paths.

(To be continued.)

Fundamental Considerations in the Reorganization of High School Science

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There has never been a time in the history of secondary education when consideration of the fundamental principles underlying high-school science courses was as necessary as at the present hour; nor has there been a time when those principles were receiving the attention they are now receiving. The Spencerian conception of science as a foundation for all general education has not been realized. The popular interest in science which characterized the epoch of Darwin, Huxley, and Agassiz, of Faraday, Lyell, and Tyndall has largely waned in recent years. The last decade of the 19th century and the first decade of the 20th century showed a marked decrease in the *percentage* of high-school students enrolled in the science classes of the secondary schools of the United States. Meanwhile, *applied* science advanced by leaps and bounds. Its controlling influence in the daily life activities of all classes increased at a tremendous pace. Within a life's span it has completely revolutionized all systems of transportation and communication; it has all but annihilated time and space; it has molded all civilized peoples into a single, interdependent community; it has transformed the primitive home into the modern home with its multitude of labor-saving and life-conserving conveniences; it has, in a large measure, severed the fetters of hard manual labor from the farmer, the mechanic, and even from the common laborer; it has enabled man to subdue and harness the vast, wild forces of nature to an extent undreamed of by the Jules Vernes of a half-century ago; it has multiplied the productive resources of human effort many fold; in short, it has doubled and redoubled the available comforts and pleasures of life and, at the same time, it has cut in half the necessary hours of human toil.

In such an age, when applied science rules the activities of men, when all human activity is so dominated and determined by applied science, why should not popular interest in science be ever increasing? Why this decline in the percentage of students who are pursuing the science courses offered in our high schools? Why the present unrest and agitation by science teachers and students of education concerning science instruction in our high schools?

Why the persistent demand, from every quarter, that high-school science be reorganized?

If science is ever to become the basic foundation of a general education for the common people, as was held two or three generations ago to be inevitable, not only by Herbert Spencer, but also by many of the leading educators of that day, science in our high schools must be reorganized. It must be reorganized with a conscious recognition of the fact, that we are now living in the 20th century, that we have passed the period when initial interest in science rests with a mere appreciation of the great, general, abstract truths of science, if indeed, young people of high school age ever were interested in that phase of science. Today, the world, outside the school room, thinks in terms of applied science, of practical science. It is absolutely clear that at the present time our classroom instruction must reveal to the high-school student something of the story of the discovery of the great truths of science but especially it must make clear to him the monumental effects of applied science upon modern life.

The science courses offered some thirty to forty years ago, when the public high school was in its infancy, were interesting and popular. But the courses then offered were largely of the nature of popular science; they were spiced through and through with details and illustrations of interest to the common people. Some of us are inclined to smile at those early courses today because they were so brief, because they dealt so largely with the spectacular side of science, and possibly even because they were evidently so framed up as to make a strong appeal to the interest of the young people. On the other hand, students of education are coming to recognize that the greatest value of those early courses lay in the appeal they made to the interest of the student.

Gradually elementary courses in science became more and more barren of detail and almost devoid of those touches of human interest which made the earlier, popular presentation fascinating. Gradually, but surely, high-school science became a condensed epitome of the college course; the dry bones of the college course were presented but the flesh and blood were gone, and with the flesh and blood went also the interest of the student.

The present organization of science materials into the special sciences for purposes of instruction, in the early years of the high school, at least, is fundamentally unpedagogical and is largely re-

sponsible for the decline of interest in science in our secondary schools. The usual course in any special science either presumes that the student is interested in the abstract, fundamental truths of science or else it neglects the element of interest as a factor in the educational process. In either case it is unpedagogical and a fatal mistake, for initial interest in science rest chiefly, if not solely, in those phases of applied science which have to do with the control of our environment, and without interest little educational progress is possible.

The units of applied science are fundamentally different from the units of "pure science." The units of applied science are the natural, Creator-made, units; the units of pure science are artificial, man-made, units. Because the mature scientist appreciates and sees a certain significance in the organization of science materials into man-made units, it does not follow that the boy or girl just beginning the study of science is likewise interested in such a so-called "logical" study of abstract, fundamental principles. The adolescent is distinctively an embodiment of alert, intense impulses. But with all his keenness and alertness his interest is secured and maintained only when the subject under consideration has significance, when it has direct bearing upon his welfare or the welfare of those about him. Critical analysis, long continued, followed by synthesis, and finally terminated, possibly, by a brief mention of application, *which is the method of a special science,* may satisfy the mature scientist but such a procedure kills all interests in the beginning high-school student. The beginner in the study of science is interested only when the order of procedure is reversed. He wants, first of all, to see the *go* of things; he must first of all be shown the worthwhileness of the task set before him. This can be accomplished only by showing him the significance of science in its applied setting. Out of a study of applied science all essential laws and principles may be developed.

As a concrete example of the foregoing let us consider the procedure of special science organization of plant life, botany. Where is the wide-awake, fourteen-year-old farmer boy who is interested in a two or three-week analytical study of roots, followed by a similar study of stems, then of leaves, and finally of fruits even though some mention of application may be made in the closing chapter? Such a boy, however, with red blood in his veins, is intensely interested in the study of corn, or of wheat, or of potatoes,

the conditions under which they germinate or sprout, and under which they grow and mature. He is interested in the climatic conditions and the soil conditions best suited to their growth and maturity, and in the insect pests to which they are subject. When science teachers come to recognize that the source of interest for the high-school boy lies in the applied phases of science and not in the abstract phases, or "pure science" phases, they will cease to wonder at the fact that agriculture is popular and on the incline as a high school subject while botany, as generally taught, is unpopular and on the decline.

The mastery (?) of some two or three hundred abstract principles and laws, together with the solving of several hundred mathematical problems and the performing of fifty or more generally non-significant laboratory exercises is usually recognized as the sum total of an adequate high-school course in physics. Such a course has been the bane of life and the Waterloo of thousands, if not millions, of perfectly normal high-school girls. Their frantic efforts to surmount this obstacle to their goal, graduation, is pathetic. But who will say that the average girl cannot be interested in, and led to appreciate and to understand, the essential principles of that most difficult portion of physics, mechanics, when we see her sitting confidently at the steering wheel of the family car safely guiding it through the crowded thoroughfare of the city? The fact is that she is easily capable of intense interest in gears, in revolutions per minute, and in differentials, as well as in proper mixtures, induction coils, magnetos, spark plugs, and storage batteries provided these be taught, not as abstractions, but as vital parts of the car she drives.

But the question arises, Just how is this reorganization of science upon the principle of developing the essential laws and principles out of a study of applied science to be effected? Or again, Is it possible to organize science materials, while following such a plan, into logical units of instruction having educational value?

Time and experience alone can fully answer the first of these questions. At the present time, however, a partial answer, and answer so far as the first course in science is concerned, is being worked out. Some of the one-year courses in general science now available is the tentative answer. Natural science, *organized knowledge concerning nature,* is not a static thing; it is ever changing; it is ever expanding and presenting new insights and new

problems concerning human welfare. Likewise, no course in general science can long remain static; it must be modified and adapted to the ever changing content of our knowledge concerning the natural world about us. Nevertheless, certain fundamental principles of organization would seem to be permanent and abiding. It is the purpose of this paper to point out some of those permanent fundamental principles.

Schematic or Graphic Illustration of the Organization of Science Courses.

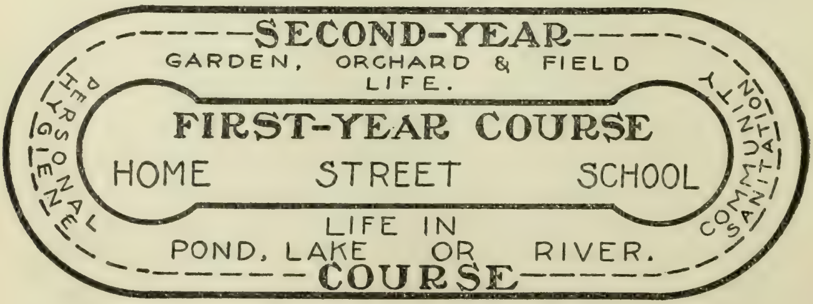
Unsatisfactory and incomplete as it must necessarily be, schematic or graphic illustration of courses of study is frequently of value because it gives at a glance the essential features of the organization. A common organization of science courses, as they have been arranged in the past, is shown by the following:

1st Year		2nd Year		3rd Year		4th Year	
Phys. Geog.	Physiol.	Zoology	Botany.	Physics	Physics	Chem.	Chem.

The Biology Committee of the National Educational Association presented the following scheme at the meeting in July, 1916:

General Course Required				Elective Courses	
1st Year		2nd Year		3rd Year	4th Year
Physical Science	Plant Life	Animal Life	Man	The Special Sciences.	

Such an organization as is presented in either of these schemes has aptly been styled a "vertical stratification of science". In contrast to any similar organization of science courses we suggest the plan shown in the following diagram, as indicating the field or scope of general science courses covering the first two years:



Such an organization of science presumes that the science materials for the first year's course shall be selected chiefly from the applications of science as found in the home, in the school and along the street leading from the home to the school. Naturally, physical science materials, such as lighting and heating systems, refrigeration, water supply and sewage disposal, the use of labor saving machines, together with the weather, climate, food and nutrition, microörganisms, and similar materials will chiefly comprise the course and personal and community welfare will be the crucial point of attack. The second year's course will reach out on every side for materials and will include plant and animal life as found in the garden, the orchard and the field, in the pond, river, or lake. It will also include a more complete study of personal hygiene and community sanitation. The second year's work will, therefore, deal chiefly with biological materials although the influence of physical environment will everywhere be an important consideration.

Science materials as commonly organized in the special sciences may properly be said to be organized into man-made units while the materials in general science may properly be said to be organized into Creator-made units. Nature presents no fundamental relationships, no functioning activities, which necessitate the study and comparison of all the forms and variations of roots, then of stems, then of leaves, and finally of fruits before a student may proceed to study and acquire an understanding of the essential characteristics of the corn plant and of the conditions best suited for its growth and maturity. Nature presents as a logical unit of study the *relation between* the root of the corn, the stem of the corn, the leaf of the corn, and the fruit of the corn. The entire corn plant, together with its relation to the soil, to moisture, to climate, and to the animal life which affects its growth is the natural, Creator-made unit. A study of corn, then of wheat, then of clover, then of the potato, then of the beet, then of the onion, and so on, until the plant life of the student's environment enables the student to grasp all of the essential principles taught in special science and at the same time approaches the various problems along the line of his natural interests.

Similarly, there is no intrinsic value to the girl in the study of all forms of gears, and all the various systems employed in the transmission of mechanical power before she is permitted to study

a concrete case. The girl who drives a car is certain to be interested in the transmission system of her own car and she delights in obtaining such a knowledge of it as will enable her more completely to control her car as a result. But the real unit of study which appeals to her as logical and natural includes the essential mechanical features of the car; it includes not only the transmission system, but it includes as well the source of power and the controlling devices; it includes proper mixtures, proper timing of ignition, spark plugs, magnetos, and storage batteries as well. Moreover, she must see all of these in their proper relation to each other. Such an organization is the Creator-made unit, the unit of applied science. Such an organization presents the unit which has significance and therefore is of interest to her. Such an organization may properly be called a "horizontal stratification of science" in contrast to the "vertical stratification of science" as presented by special science.

There is positively no difficulty in organizing the science materials involved in such courses into suitable, logical units of instruction of as great, if not greater, theoretical educational value as the usual units of special science. In addition, experience shows the writer that such an organization of science materials secures and holds the interest of the student with the result that a permanent, abiding interest in science is developed and a permanent scientific attitude of mind results.

It is as yet a question whether the recommendation of the Biology Committee, that the last two years of the high-school course shall be devoted to the study of elective special science, is the best possible solution. It is doubtless true that with greater maturity and with fuller knowledge of the significance of science there comes a time in the life of each of us when we do develop an interest in the abstract, philosophical aspects of science. Whether that stage is usually reached by the student when he enters upon his junior year of high school work is a question. Many students of education doubt it. In any case it would certainly seem wise that in most high schools specific courses in agriculture, domestic economy and household science should find a place in the last two years of high-school course.

The Special Scientist's Contention.

The contention is made by some of the advocates of special science that the reorganization of high-school science along the lines

here proposed means the reversing of the wheels of progress in all science teaching. It has been generally admitted that science instruction in our high schools has been at least a great disappointment, if, indeed, not a near failure. The special science teachers in colleges and universities have been bold in declaring that the work done in the high school has to be done over again in the college classes; they say that there is really little difference in the progress made by those who have had the high-school work and those who have not. But some of the advocates of special science insist that we are just now at the turning point; they say that we are just now realizing our mistakes, that we have just discovered how to adapt the subject matter and methods of instruction so as to secure and hold the interest of the students and to teach science courses successfully. In short, they say that we have just learned that special science courses must be humanized. Moreover, they point out the fact that all college and university instruction prepares the young high school teacher to teach special science. "If these teachers have not made a success of teaching special science in the high school", to quote the thought of one of their most distinguished leaders, "the mess they would make of it were they to attempt to teach general science must be left to the imagination." In general, they say that to abandon the teaching of special science, in a part or all of the high-school course, and adopt the general science organization would mean the forfeiture of the progress made, and a loss of the benefit of the experience gained, during some two or three generations of science training and science teaching and to turn a well-ordered, logical system of instruction into confusion and chaos.

The Answer.

These champions of special science have not yet proved, nor do we believe that they can prove, that any of the special sciences as now taught in the high school are gaining materially in interest, popularity or effectiveness. Nothing is more evident than that physical geography and physiology, commonly first year science courses, never before suffered so great a decline as during the past two years. First-year general science has already largely displaced them. Botany and zoölogy are, in many sections of the country, giving place to agriculture. The record of higher institutions requiring elementary physics and chemistry for entrance to certain courses show an ever increasing percentage of applicants knock-

ing at their doors without these prerequisites. If special science courses are really gaining in popularity, interest or effectiveness, available records do not reveal the fact, nor does the testimony of students, science teachers and administrative officers reveal it.

Again, however true the contention may be that college and university courses in science prepare the young teacher for teaching special science only, this fact does not justify the retention of such courses in the early years of the high school, if our contention that such courses are unsuited to the interests and needs of beginning high-school students is valid. If special science is not in harmony with the foundation principles which underlie successful science teaching in the early years of the high school, the remedy lies only in a readjustment of the science courses in such colleges and universities as aspire to prepare high school science teachers. The public high school exists for the benefit of the children of the common people; it must be so organized as best to serve the interests and welfare of the millions of young people who must complete their education within its doors. If the usual courses in special science now offered by the higher institutions do not prepare the teacher to teach general science, colleges, universities, normal schools, and teachers colleges have no alternative but so to adjust their courses that their graduates *can* properly handle the courses required by the high school. The higher institution cannot longer expect to dictate the courses and the methods of instruction in the high school but must so prepare teachers that the best interests of the high school may be conserved.

It is not certain, however, that teachers fairly well prepared to teach the special sciences cannot also teach courses in general science with fair success. In all the smaller high schools, the country over, science teachers are now teaching, not a single science, but often all the sciences and frequently other branches, such as mathematics, literature or history. It is common practice to require the science teacher in such schools to take charge of the work in agriculture or domestic science. Furthermore, during recent years, courses in general science have been taught in many schools by these same teachers trained only in special science. That such courses in general science are being continued year after year and are, in general, being pronounced a success would seem to be a sufficient contradiction to the statement that our present corps of science teachers are not fairly well equipped to teach general science.

SUMMARY.

It is our contention that special science in the high school has been a disappointment, if not a near failure, not chiefly on account of poorly prepared teachers but chiefly because the selection and organization of subject matter and the methods of approach and development have been fundamentally unpedagogical. The natural interest of the student just beginning the study of science lies in the applied phases of science as it affects his own personal welfare and the welfare of the community in which he lives. The fourteen-year-old boy or girl is not a philosopher; abstract generalizations and principles of science, that is, special science as usually taught, so-called "pure science", is foreign to his interests and his ways of thinking and is therefore distasteful to him. Only the genius, the teacher of unusual personality and ability, and who is inspired by his own devotion to the subject can interest a class of beginners in that phase of science. The ordinary teacher, on the other hand, who is fairly well prepared in the academic phases of science, can succeed fairly well with the beginning class if the materials are organized as general science and the materials selected deal with the applied phases of science as found in the environment of the student, because he then has the natural interest of the student to aid him.

The reorganization of high-school science in substantial conformity with the fundamental principles here set forth seems certain to come in the near future. Live science teachers, administrative officers and students of education are everywhere studying the question with interest and sincerity. The exact form of the reorganized courses will be determined only by time and experience but the fundamental principles upon which the reorganization will rest appear to be pretty well established.

Twilight

By W. G. WHITMAN, State Normal School, Salem, Massachusetts.

Anyone who has ever been in a brilliantly lighted room when all the lights have suddenly gone out, understands the bewilderment and feeling of utter helplessness which comes to one whenever there is a sudden and unexpected change from light to darkness. With this thought in mind we can better appreciate the beneficient

effect of our atmosphere in causing a gradual merging of day into night. Were it not for the atmosphere about the earth, when the sun sinks below the horizon we would be plunged instantly into dense darkness. We would need to light all our houses at once. An entire city would be lighted at the instant of sunset or earlier. How different that would be from the leisurely manner in which we are now able to do our lighting. With the exception of cloudy days, it is light enough after sunset for a good deal of work or play without the use of artificial light.

It is an interesting spectacle to look down upon a town just after sunset from a neighboring hill. At first a solitary light appears now here, now there. Later their number increases rapidly until nearly all the houses and streets are dotted with lights. All this happens and it is still light enough to see the path down the hill to town. In the indistinct light of evening details are softened, mysteries abound, and the charm of it all fascinates us. Poet and artist have been inspired by it and have recorded their emotions in verse and painting. The frontispiece "Evening Twilight" in this number of the Quarterly is from Charles H. Davis' "Evening", a painting which hangs in the Metropolitan Museum of Art in New York.

> O Twilight! Spirit that dost render birth
> To dim enchantments; melting heaven with earth,
> Leaving on craggy hills and running streams
> A softness like the atmosphere of dreams.*

Twilight summons the owl, the night-hawk and the whip-poor-will to activity. Twilight brings forth the frog's song and awakens the katydid. Morning twilight is the one time of the day for the greatest rejoicing among the birds; then it is that the bird lover goes out if he would be present at their music fest.

There are certain flowers, too, which seem to be inspired by twilight, at least they are stimulated to open their blossoms and to pour forth their fragrance at that time. As some of our most beautiful flowers are only found skirting the perpetual frost, so others are never found except they are sought along the borderland of night. Have you ever had the pleasure of watching the buds of the evening primrose unfold into blossoms at dusk? How quickly the air becomes laden with sweet fragrance! Perhaps you have seen the sweet-scented evening stock, which has been drooping

*From poem by Caroline E. S. Norton, (Lady Maxwell).

listlessly all day, straighten, blossom, and pour out its delicious perfume upon the cool twilight air. Nicotine, inconspicuous with its limp and lifeless trumpets during the day, attracts your attention in early twilight by its penetrating fragrance and its beautiful white star-tipped trumpets. These evening flowers are visited by moths and humming birds; the fragrance aids in attracting their attention.

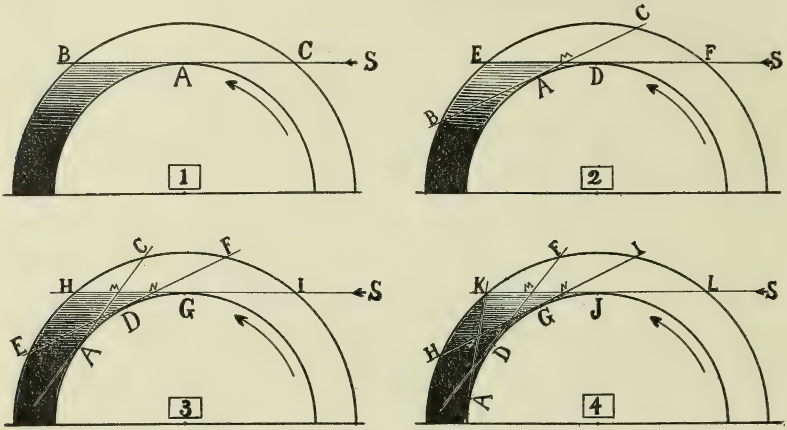
If you are not naturally curious about natural phenomena, you probably never have questioned the source of this light which is not only so useful but so pleasant to us at the close of day, which so cheers the birds in the early morning, and which makes the blossoming time of some of our most fragrant flowers.

When the sun has gone below our horizon we are in the shadow of the earth; but the air above us does not pass into this shadow at once. As long as some portion of the atmosphere above our horizon receives light direct from the sun, the particles of dust and moisture in the air will reflect more or less light into the shadow to us. This reflected and diffused light is called twilight. A similar twilight occurs before sunrise in the morning. The morning twilight is commonly called dawn. Above forty miles the air either is so rare or so lacking in suspended particles that no sensible light is reflected.

The boundary line between the illumined atmosphere and the darkened portion below it, is sometimes so marked that it may be observed. Soon after sunset this curved boundary line known as the "twilight bow" may be seen to rise in the eastern sky. It has a reddish color and diminishes in intensity, usually disappearing before it reaches the zenith. As the twilight enchanter sweeps the sky with this magic wand a veil is drawn aside and behold: the marvel of night is disclosed with her thousands of sparkling eyes.

The transition from day to night through twilight is so gradual that the bounding limits cannot be told except by indirect means. Twilight begins at sunset, but we see no sudden change in light at that time. When the eastern limit of the illumined atmosphere is at our zenith first magnitude stars are visible in the eastern sky. Toward the end of twilight the sky is dark except that a faint glow of light may be seen near the western horizon. Twilight ends when sixth magnitude stars are visible in the zenith. At the end of twilight the sun is about eighteen degrees below the horizon. In Europe the term *civil twilight* is applied to that portion of twilight

in which it is light enough to continue outdoor occupations. Civil twilight ends when the sun is about 6° below the horizon. Occasionally a glow is seen in the west after true twilight has ceased. This "afterglow" is thought to be doubly reflected light; that is, light reflected from twilight into darkness.



Figures 1-4. Source of Twilight. The depth of atmosphere is greatly exaggerated. If drawn to scale, A in Fig. 4 would be approximately 18° from J.

In Figures 1-4 the earth's surface is represented by the inner semi-circle and the atmosphere by the space between the two semi-circles. Let A (Fig. 1) be a point on a broad plain of the earth's surface and BC the horizon. The last rays of the setting sun are on the horizon line. All the atmosphere above the horizon of an observer at A is in direct sunlight. Because of the eastward rotation of the earth the observer at A is quickly moved from the daylight zone into the shadow and the twilight bow begins to rise in the east. When the point A has reached a position shown in Figure 2 the observer receives diffused light from the upper layers of air included by EMC. The lighted space above the observer's horizon is ever diminishing; when the observer has reached a position, A, shown in Figure 3, he receives light only from HMC. Finally his horizon line toward the west passes outside the lighted portion of the earth's atmosphere (Fig. 4) and twilight has ended.

The duration of twilight varies greatly in different parts of the world; it also varies in any one given place. The length of twilight depends upon the condition of the atmosphere, the elevation, the season and the latitude.

A clear atmosphere devoid of all particles of dust and moisture has little power to reflect light. The number of these particles varies and so the amount of light reflected into the earth's shadow varies. A decrease in the intensity of reflected light shortens the twilight.

The height of overlying air capable of reflecting light is less on a mountain top than it is at sea level. Because of this and the fact that in mountainous regions the air is very clear, twilight on high mountains is short. On some mountains in the tropics twilight is reported to be less than twenty minutes in duration. Just east of a high range of mountains or in a deep narrow valley twilight is short because of the limited extent of illuminated sky above the horizon.

Because of the inclination of the earth's axis to the ecliptic and the variation in the time it takes for the sun to reach a point eighteen degrees below the horizon, twilight varies at different times of the year and varies with the latitude of the observer.

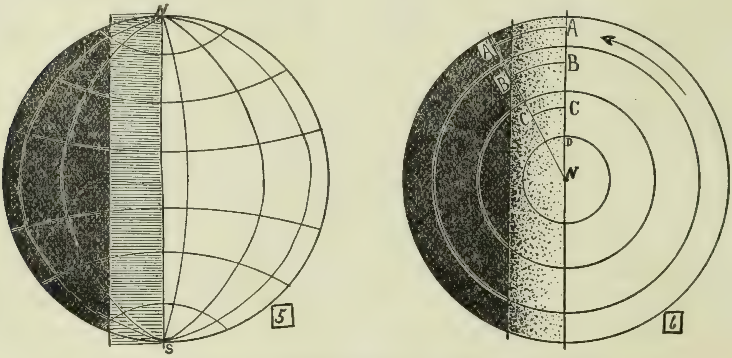
Figures 5 and 6 show the earth in spring and fall at the time when the length of daylight equals that of the night and twilight together. Daylight reaches both poles and a belt of twilight nearly 1500 miles in width extends entirely around the earth. This belt is bordered on one side by daylight and on the other by darkness. Figure 6 is a view of 5 as seen when one looks down on the north pole. The outer circle represents the equator. Let us consider three places A, B, and C, which are in different latitudes and which are just entering the twilight belt. These three points describe complete circles in 24 hours; it is evident that A, since it describes the largest circle, moves faster than B, and B moves faster than C. When B has just crossed the twilight belt and reached the point B′, A had reached A′ and C had reached C′. It is thus seen that a point on the equator passes through the twilight belt quicker than any point either north or south of it. Kipling suggests the brief twilight of the tropics thus:

> "An' the dawn comes up like thunder outer
> China 'crost the Bay."

Any point within 18° of the poles such as D remains in the twilight belt 12 hours on March 21 and September 23.

A study of Figures 7-10 will readily show that as a result of the difference in the relation of the sun's daily path to the horizons of observers in different latitudes that the distances the observers

traverse in order to cross the twilight belt vary with their latitudes. For example, compare the distance that A must travel with that which B must travel to cross the belt (Figures 8 and 10). Even if their rates of motion were the same, the time required to cross the belt would be greater in the higher latitude because here a point on the earth passes more obliquely across it. In polar regions a point may not cross the twilight belt, but instead describe a circle partly in it and partly in darkness (D in Fig. 8) or it may describe a circle partly in twilight and partly in daylight (D in Fig. 6 and C in Fig. 10).



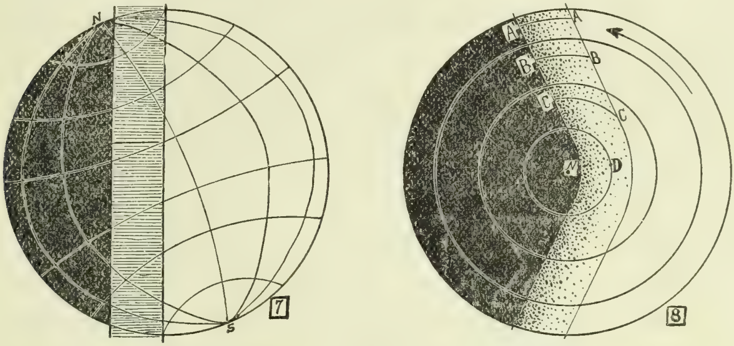
Figures 5-6. Twilight Belt in Spring and Fall.

The twilight belt migrates back and forth across the poles. On December 22 the north pole is in darkness (Fig. 8). A few weeks later it enters the twilight belt, in which it remains until March 21 (Fig. 6). On this date it enters a six months' period of sunlight (Fig. 10). On September 23 the pole again enters the twilight belt (Fig. 6) which it crosses in a little over two months. During the latter part of this twilight period it is darker than during the first part of it, but the reverse is true when the pole emerges from darkness and approaches the daylight.

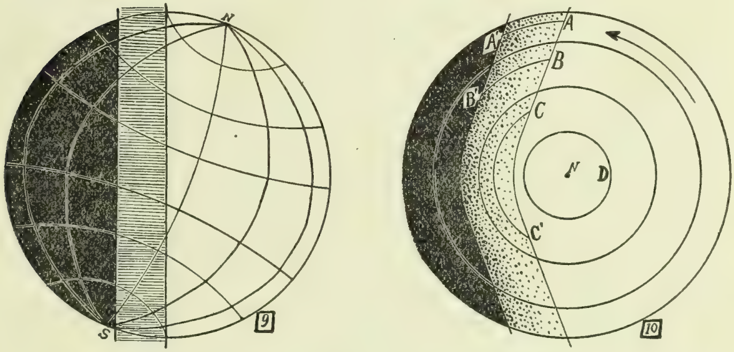
In latitude 42° twilight is longest in June when it lasts about two hours; it is shortest in February-March and September-October when it is less than one and a half hours. In latitude 50° twilight is more than three hours long in June and but little over one and a half hours in February-March and September-October. That twilight is longer in December and January than it is in the months preceding and following is due to the fact that we pass through the twilight belt more obliquely in winter than we do in

early spring and late fall. This can easily be understood by reference to the diagrams (Figs. 6 and 8).

In low latitudes there are two twilights in twenty-four hours but at the poles there are only two twilights a year; and these are



Figures 7-8. Twilight Belt in Winter.



Figures 9-10. Twilight Belt in Summer.

several months in duration. In some latitudes between these there are places where evening and morning twilights blend, making one twilight each twenty-four hours (C in Fig. 10 and D in Fig 6.). In England there is no real night from May 22 till July 22. Daylight and twilight make up the 24 hours of the day. Perhaps this is one of the most interesting experiences the newly arrived American has in England when he reaches that country in June. For then he is able to read a daily paper on the street as late as 9.30 P. M. without artificial light. In latitude 60° it is light enough in summer to read large type during the entire "night", which is not true night at all but only twilight.

What the Chemist Can Do for Medicine*

By Alfred W. McCann, New York.

Do pathogenic organisms (tuberculosis, typhoid fever, scarlet fever, diphtheria, septic sore throat, etc.) thrive or die in blood, the specific gravity of which is normal? If any living chemist or bacteriologist could answer this question tonight he would stand forth the most conspicuous member of his profession.

It is now definitely known that the specific gravity of the blood can be changed at will through the instrumentality of diet. Minerally deficient food affects with extraordinary rapidity the specific gravity of all the internal secretions. Animal experimentation, conducted in hundreds of laboratories throughout Europe and America, yields abundant data with respect to this phenomenon, the significance of which has been ignored by the medical profession and the biochemist.

It is now known that the functions of the mineral substances found in the internal secretions may be summarized as follows:

1—To regulate the specific gravity of the blood and other fluids of the body.

2—To regulate the chemical reactions of the blood and the various secretions and excretions.

3—To preserve the tissues from disorganization and putrefaction.

4—To enter into the permanent composition of certain structures, especially the bones and teeth.

5—To enable the blood to hold certain materials in solution.

6—To serve special purposes, such, for example, as the influence of chlorine on hydrochloric acid formation, the influence of calcium in favoring coagulation of the blood, the influence of iron in the formation of blood pigment, the influence of potassium on the elasticity of the tissues, etc.

That it has never occurred to the medical profession to note the changes that take place in the specific gravity of the blood and other internal secretions or to interpret the significance of such changes, constitutes one of the curious lapses of the scientific world. It is known that in anemia, cup-shaped corpuscles are found. Anaesthesia also produces cup-shaped corpuscles. In fevers the

*Address before the Chemistry Teachers' Club of New York City, in October, 1916.

corpuscles are wrinkled or cerated. These facts are significant in connection with the popularly accepted theory that the red corpuscles of the blood always appear as discs, slightly hollowed on each side.

Physiologists have noted cup-shaped red corpuscles, concave on one side and convex on the other. Failing to interpret the shape of the corpuscle as a symptom of some change in the specific gravity of the blood, they have announced what they believed to be discoveries concerning their true shape. Arey, of the Northwestern University Medical School, reports experiments which prove that the form of the corpuscles depends on the density of the serum in which they float.

Normal, freshly-drawn blood has disc-shaped corpuscles. When diluted with 40% water the corpuscles of normal blood become cup-shaped, possibly for the reason that the dilution causes them to swell. When 70% water is added to normal blood the corpuscles swell until they become spheres. By withdrawing water from the serum the corpuscles shrink until their margins become wrinkled. If corpuscles thus change their shape, due to the absorption of water in one case and the giving up of water in the other, to what extent does the change of shape, due to the altered specific gravity of the fluid in which they are bathed, modify their functions?

Normally fed animals in whose diet appear the salts and colloids of calcium, potassium, iron, phosphorus, manganese, magnesium, sodium, sulphur, silicon, chlorine, fluorine, iodine, are able to develop immunity to many diseases. We are quite certain that all forms of malignant diseases are possible only because of the absence of or loss of this immunity. The experiment stations of Europe and America have clearly established the fact that all animal life in normal state of environment and supplied with nutriment containing all the organic ingredients necessary for the upbuilding and maintenance of a disease-resistant vitality, possesses in itself a protective immunity to cancer.

The hundreds of experiments (such as those of Voegtlin and Towles) with foods of high caloric value deprived of their mineral salts demonstrate the inadequacy of such foods. One-sided nutrition with refined carbohydrates, proteins and fats is followed by immediate reactions in the internal secretions. Deprive the living organism of the mineral salts found in these secretions and the specific gravity of the blood must undergo a morbid change.

If this change is followed by a mangling, strangling, withering or bloating effect upon the corpuscles, to what extent do the corpuscles, under such conditions, both fail to perform their natural functions and set up possible morbid activities which destroy equilibrium?

The chemist, particularly the biochemist, has in the field of nutrition an opportunity to enlighten the medical profession with respect to the significance of the morbid conditions that follow a disturbance of the normal specific gravity, not alone of the blood but of all the internal secretions.

The extent to which natural immunity may depend upon the specific gravity of the blood has never been suspected. The extent to which the unnatural modification of the shape of the normal red corpuscle may influence the vitality of the human organism has never been suspected. The results of hundreds of experiments, indicating the general necessity of unmilled, unrefined, undenatured foodstuffs in the diet of man and animal, are on record. The manner in which these results are ignored by the modern dietician as well as by the medical profession is undoubtedly due to the failure of chemistry thus far to determine the exact significance of the specific gravity of the normal internal secretions and the effects which follow any departure from normal in such secretions.

The chemist who will make clear to the medical profession the significance of these obviously vital suggestions is destined to be looked upon by future generations not only as the father of a new school of medicine, but as a benefactor of the human race second only to Pasteur. To date the chemist has not been sufficiently interested in the physician or the physician sufficiently interested in the chemist to bring about between them a keener appreciation of the services that both working together, might render to humanity.

The chemist knows, for instance, that the specific gravity of the blood depends largely upon the base-forming elements of food and that these base-forming elements are to be found chiefly in ripe fruits, grasses, fresh green vegetables and pure milk, whereas animal foods, other than milk, and the seeds of grasses, such as cereals, supply the greater share of the acid-forming elements. It is known that vegetable matter does not decay nearly as readily as animal matter, the putrefaction of which begins shortly after it is acted upon by the digestive ferments.

Vegetables are just as thoroughly digested in the intestinal tract

but the extreme decomposition processes which follow digestion are not initiated nearly as quickly in vegetables as in meat. It is known, for instance, that the extreme decomposition of food which makes for putrefaction is responsible for certain types of auto-intoxication. On a diet of bread, vegetables and milk (by bread I mean whole meal bread) these forms of auto-intoxication, unless brought about by some constitutional disorder, are never encountered. One of the most obnoxious products of the putrefaction of proteins is hydrogen sulphide, which has distinct acid properties and which is therefore broken up under the influence of base-forming food. It is not known to what extent hydrogen sulphide in the absence of bases affects the iron content of the blood or other internal secretions. Certain foods like meats are incapable of supplying the bases necessary to neutralize the hydrogen sulphide. Unrefined vegetable foods do supply these neutralizing bases.

When the chemist shows the physician just what happens when the specific gravity of the internal secretions is modified abnormally and just how refined and unrefined foods of vegetable or animal origin bring about this modification, a new era of public health activities will be inaugurated. When the chemist, instead of being engaged in the defence of food abominations with all the odium that attaches itself to these pernicious activities in which eminent college professors have so frequently appeared to the disgrace of their profession, he will be looked upon with a newer and greater honor as the most important of all the influences operating to the development of the healthy normal child and the elimination of the many preventible tragedies of maternity that now contribute so much to the sum-total of human misery.

The Chemist

By Schaler Seton

He carries in his hand a shapely glass;
Within, a liquid, colorless and clear,
Reflects the sunlight, but there doth appear
No trace of solute in its limpid mass.
He drops a crystal in. Then comes to pass
A miracle; what once had seemed asleep
Awakes to beauty; lace-like fingers creep
Through the solution, growing like the grass
Till all turns solid. Once in ages dim
God held the world inchoate in His hand.
He dropped a thought in; at the great command
The solid earth first reared to the sun's beams.
So, in his mimic art the chemist dreams
And strives to think God's deep thoughts after Him.

A Twenty Minute Project

By Dwight W. Lott, High School, Lima, Ohio.

We have read many articles in favor of and a few articles against the project method of teaching science. We have heard educational experts deliver addresses which convinced us that the only way an individual, in school or out of school, ever solved a real difficulty was by the project method. So we concluded to use that method in the teaching of science.

But where are we to get our projects? We have seen no printed outlines of projects. We have ventured to ask the educational expert for them, but quite often he replies with much enthusiasm, "My friend, there are hundreds of projects. The world is full of them." Sometimes he states that his field is that of educational philosophy and the bewildered science teacher is left to infer that workable science projects do not grow in that particular field. However, the teacher has received splendid inspiration and many guiding principles from the philosopher.

During the last three years the writer has tried to develop projects for class room use. Ten or twelve hours were often spent in the preparation of a single project. Great care was taken in trying to foresee the psychological time for asking certain questions and for doing certain things. Demonstration experiments were devised and prepared, though not always used, in order to answer experimentally certain questions which the pupils might ask.

As a result of this experience I have not lost faith in the project method. Some success was attained although signs of failure were in evidence quite often.

Several of my "best" projects seemed to be failures. It was like unloading manufactured goods at a station where nobody wanted that brand of merchandise. They wanted "home products." My pet experiments were not called for. If performed at all they were forced on the pupils. The pupils could not sense the problem, did not ask "appropriate" questions, could not organize what material they already had, could not suggest a reasonable hypothesis or could not deductively test the validity of its consequences if they did suggest one; in fact, they were unable or at least unwilling to perform any of the tricks prescribed by our philosopher guides.

Some of my "weakest" projects seemed to be very successful, and some of the most successful ones originated during a class room discussion, were developed and were solved without any outline having been prepared previously by the teacher.

Some of my "best" projects were failures because they were artificial; they had been manufactured to meet a need which was not felt by the majority of the pupils. Logically they were fine; psychologically they were inferior at the time presented. Some of them might have worked well under different conditions but those conditions did not exist at the time of the recitation. Others did work splendidly.

We may safely say that teachers are very rare who can foretell what the composite mood or spirit of a class will be on Thursday of next week or on Monday of the week after next. The same is true with respect to the emotions of the individual pupils. That the emotional element plays a dominant part in the educative process is expressed by Dewey as follows: "Knowledge is impossible without feeling and will."* Also, "Wonder is not only the originator, but it is the continuer of science. Wonder is the emotional outgoing of the mind toward this universe."†

I have come to believe that the most practical projects are among those which arise naturally from the emotions of the pupils. I have not said that every project suggested by a pupil is practical. It is the duty of the teacher to recognize them instantly and select promising ones for solution by the pupils.

So at the beginning of the fourth year's experiment with the project method, we have chosen the motto, "Fewer artificial projects and more natural projects." We have about 325 pupils in general science. They are divided into twelve sections. Each pupil has a text, a splendid book too, yet we have considered the idea of assigning lessons in the text as being artificial. We believe that over half of our pupils study an assigned lesson more because it has been assigned than because they have any natural desire to study. We have now reached the end of the twelfth week and not a single book lesson has been thrust at our pupils. However, at present no claims are made as to the superiority or inferiority of the total educational results of the experiment. We do claim that we have seen more intelligent use made, of textbooks and other sources of

*Psychology, p. 18.
†Psychology, p. 303.

information, by pupils than we have ever seen before during the same length of time by pupils of the same age. We still prepare artificial projects but use them only when we fail to "stir up" a natural project within five or ten minutes after the recitation begins. Often the next project develops before the present one is finished. The time required for the solution of one project may vary from a few minutes to several days.

Outlines of projects, whether made by others or by ourselves, should be considered as suggestive of what has been done or might be done under certain conditions, but not as detailed specifications of what to do under conditions "subject to change without notice."

The following project is imperfect in several ways, but is an accurate account of what happened in one of my classes this morning. It is given simply as an illustration of what we mean by a natural project.

Sunday was a warm day, Monday was less warm and this morning, Tuesday, the air was quite cold. It was the first period in the morning and the engineer was having difficulty in heating some of the rooms properly. No sooner had the pupils been seated than some of the girls asked permission to get their wraps. I had a certain definite plan in mind for the day's lesson but discarded it at once when it seemed that "the fish might bite better if the bait were changed."

Teacher. "What is the population of Lima?"

Pupil A. "About forty-two thousand."

Teacher. "What did many people talk about this morning?"

Pupil B. "They talked about how cold it is."

Teacher. "About how many Lima people do you think talked about the weather this morning?"

Pupil A. "Twenty thousand."

Pupil B. "I think about twenty-eight thousand."

Pupil C. "No, nearer twenty-five thousand."

Teacher. "Have you any questions to ask this morning?"

Pupil L. "Why does the weather change like it has?"

A pause of two or three minutes.

Pupil M. "I think I know. We get our heat from the sun, and we learned the other day that when the sun's rays hit the ground in a slanting direction, the ground does not get so warm as it does when they strike it in a direction straight down. The change in slant is what causes winter and summer. Winter is

coming and the rays slant more every day. They slant more today than they did on Sunday and that's why it is colder today."

The pupils were apparently satisfied for about a minute.

Pupil L. "Yes, but sometimes we have a warm day following a cold day at this time in the fall."

Pupil M. "That's right, my answer will not do."

Teacher. "Do you think any of Walter's statements are correct?"

Pupil K. "Sure, he was right about the sun's rays and they do slant more today than they did Sunday, but there must be some other reason."

Pupil X. "On Sunday we were getting a warm breeze and today we are getting a cold breeze."

Teacher: "Where do you think warm breezes and cold breezes come from?"

Pupil X. "The warm ones come from the south and the cold ones come from the north."

Pupil E. "Why did the wind happen to blow from the south on Sunday and from the north today?"

Pupil A. "The wind always blows from a place where the pressure is high to a place where the pressure is low. Since Sunday, Lima has been in a low pressure area."

Pupil E. "But if we are in a 'low' the air would come from all directions at the same time."

Teacher. "Recall our experiment of pouring water on the large rotating ball." A pause of about two minutes. "What would happen to a wind blowing from the south toward the center of a low pressure area?"

Pupil H. "The rotation of the earth would make the wind blow to some place east of the center."

Pupil D. "Yes, and a wind coming from the north would turn and blow to a place west of the center."

Teacher. "Will the east or west side of a 'low' have the higher temperature?"

Pupil D. "The east side ought to be lots warmer than the west side."

Teacher. "In what direction do 'lows' move in the United States?"

Pupil L. "They move eastward."

Nothing more was said for a little while. Then faces began to

beam and hands were raised. One boy was unusually eager to express himself and was given the opportunity.

Pupil L. "When a 'low' moves across this part of the country it is just like a long freight train going at slow speed from the west side of town to the east side. The engine is hot and heats up the town and there is a warm day. The caboose is cold and when it comes along we have a cold spell like today."

Teacher. "Splendid, Harold, but why did you happen to think of a freight train?"

Pupil L. "My dad's an engineer on the Pennsylvania."

Teacher. "This will be all for today."

It was a welcome sight to see more than half of the pupils voluntarily read their general science texts during the remainder of the period?

Does the reader believe in natural projects?

The General Science Situation in Oregon

G. M. Ruch, Senior High School, Ashland, Oregon.

Historical.

The beginnings of general science in Oregon date back to the year 1912-1913, when two high schools, Salem and Union, offered such a course. Both schools later discontinued the work temporarily, although Salem now provides general science in three junior high schools. During the school year 1914-1915, six schools attempted the work and all reported the results as sufficiently satisfactory to warrant the retention of the subject. These schools were McMinnville, Salem, Gold Hill, Bandon, Tillamook and Ashland. In 1915-1916 twenty schools offered general science, a gain of fourteen over the preceding year. The number for this year can only be estimated and the best date obtainable seems to place the total at about thirty-five, a splendid showing for a state with only about 175 high schools.

Methods of Instruction.

In regard to the methods of instruction, it can fairly be said that there is much yet to be desired, but progress is very much in evidence. As with all new subjects, time and experience will solve

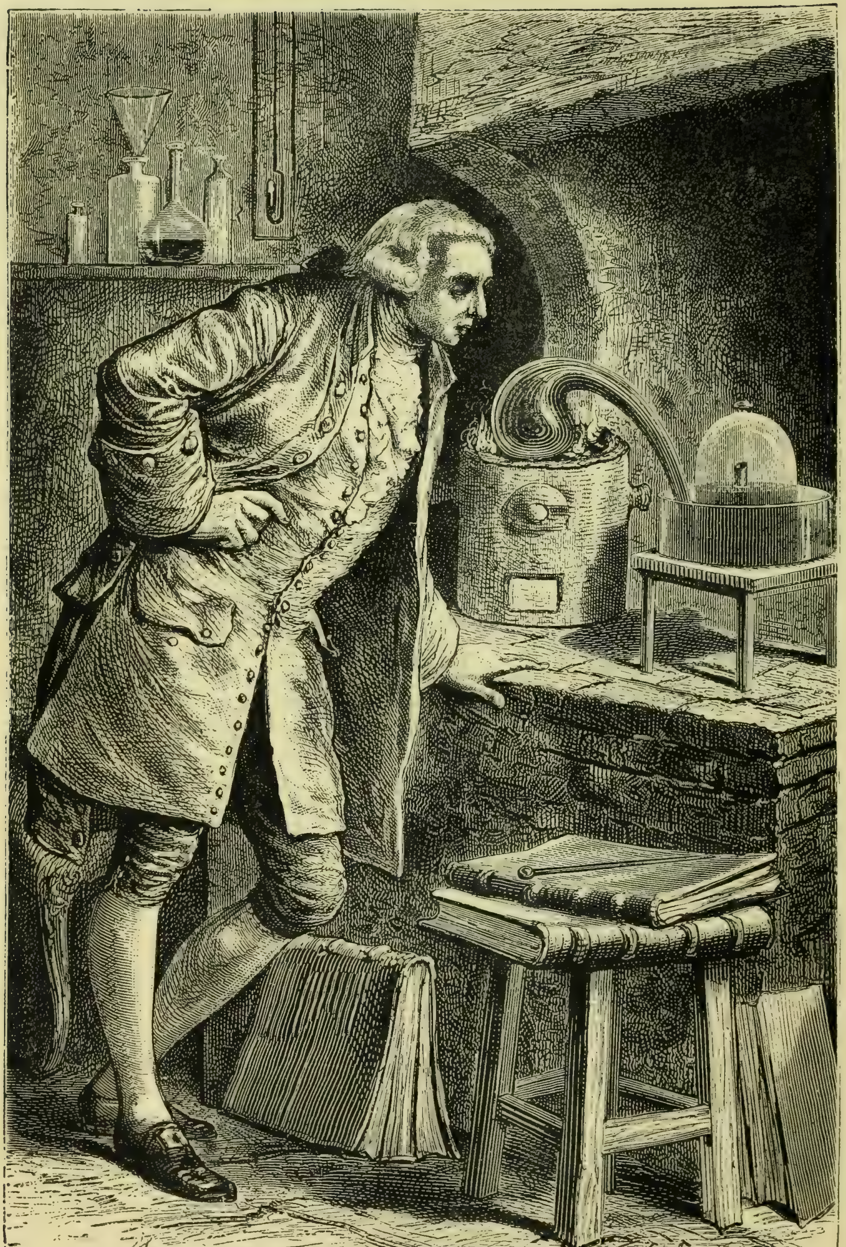
many problems. The actual working conditions as nearly as can be determined for the state at large are given in summary in the following paragraphs.

All of the schools are using regular text books and about three-fourths are using a laboratory manual as well. No particular text has proved a marked favorite but the Clark and the Caldwell and Eikenberry texts are somewhat in the lead. At least half of the schools use supplementary texts as well.

In the matter of enrollment in general science classes, the total for the entire state for this semester is nearly one thousand pupils. None of the schools segregate the sexes.

The conditions of laboratory instruction are not very satisfactory; but three schools have been able to make the laboratory work entirely individual in character. Six more make half of the laboratory instruction individual but the majority follow the plan of demonstrations by the instructor, together with careful note-book work and a small amount of individual effort. This condition can be credited to large classes and lack of proper laboratory facilities in the smaller schools. Another unfortunate condition is found in that few schools can use the conventional double period for laboratory sections. The prevailing plan is to devote three days a week to recitation and two days to laboratory exercises. Moreover, it is very desirable that each school own a projection lantern for use in general science classes, but thus far only four schools are so equipped.

The most hopeful indication of the future for general science in this state is the working spirit which exists, a spirit of optimism tempered by a desire to subject each rising problem to a careful study. Every teacher of the subject who could be induced to express an opinion has expressed the conviction that the results obtained thus far justify the retention of the subject in our curriculum, and not a single school has yet reported dropping the course because of unsatisfactory results. The number of schools preparing to adopt the new subject within the near future is encouragingly large.



LAVOISIER ANALYSING AIR

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An Interpretation of the New Point of View in Science Teaching.*

Otis W. Caldwell.

Persons who have advocated a new point of view in science teaching have constantly been objects of distrust or suspicion on the part of what sometimes seems to be the large majority of science teachers and scientists in general. There seems to be an impression that those under suspicion are personally responsible for bringing upon us a condition of unrest and a feeling of dissatisfaction. This interpretation is far from being true, since the condition of unrest and lack of satisfaction with the prevailing educational procedure is too fundamental to have been caused by the activities of a few persons. The condition would have developed, possibly not in exactly the same way or at the same time, if none of these persons had been interested in it. The interest in a new point of view of science work in schools has appeared in the work of the N. E. A. Commission on Reorganization of Secondary Schools, the publications of the committee on "A Four-Year Science Course" of the Central Association of Science and Mathematics Teachers, in discussions of a large number of teachers' associations, in the public press, and in the more recent text books published for school use. This interest has appeared independently in many different places and under widely different conditions.

A condition of unrest is not necessarily unwholesome, as is sometimes supposed, provided the condition has arisen from constructive causes. In the history of biological and geological evolution,

* Condensed from an address given before the General Science Club of New England in November, 1916.

the periods of unrest are the ones from which most distinctively new processes and new forms have emerged. In the history of a human individual the periods of greatest disturbance, provided they do not extend to chaotic and undirected expenditure of energy, are the periods from which the individual derives newer ambitions because of discovery of new possibilities. In the physical world a substance in solution may move about, and eventually becomes sediment, precipitate or crystal. It is only while in solution that there is largest possibility of reformation. A condition of unrest in science teaching represents a period of hope and expectation, and presents a most enticing opportunity to persons who really believe in science as a means of public education.

THE HIGH SCHOOL POPULATION.

One of the most fundamental factors which has influenced science teaching is found in the remarkable recent change in the number and status of those who attend the public high schools. Beginning with the first public high school in 1821, it required twenty years for the pupils in all public high schools to reach the number 2526. After seventy years of development, i. e., in the years 1889 and 1890, the total number of public high school pupils in the United States had reached 202,963. It is of especial note that in the twenty years following 1889-90 the number of public high school pupils increased to 915,061, and it is estimated that in the present school year the number of public high school pupils is well toward one and one-half millions. When there is added to these figures the pupils of secondary grade in private schools, it is apparent that the numbers have become enormous, and it is important to determine some of the factors that have had to do with this very great increase in the number of persons who are attending the secondary schools.

CHANGES IN CITIZENSHIP OF THE UNITED STATES.

It is a noteworthy fact that the population of the United States as a whole approximately doubled during each twenty-year period between 1790 and 1850. It approximately doubled again in the thirty years between 1850 and 1880, and almost doubled again in the thirty-five year period between 1880 and 1915.

In the ten-year period between 1900 and 1910 the whole population of the United States increased 11.3 per cent. During this

period, however, the city population increased 34.8 per cent., while the rural population actually declined. In some of the more prosperous agricultural states the population of the state as a whole decreased, except as it was influenced by one or two large cities. It appears that in one or two of the largest states, even when the population of the cities is included, the population of the whole state has actually diminished during the ten-year period in question.

The nature of this changing citizenship has been influenced very largely by the different types of immigration which have been dominant in different periods of the time during which the American public high school has undergone its development. The early immigration to this country was from the English, Dutch, French and Spanish countries. These were peoples who came because of their desire for intellectual and religious freedom, and they were peoples who were ambitious to have their children taught the things which were regarded as fundamental for the development of professional careers. But in the middle of the nineteenth century immigration from the above named countries was greatly diminished, and social, industrial and intellectual disturbances in Ireland, Germany and the Scandinavian Peninsula, together with the appeal that was presented by the unused opportunities of America, stimulated immigration from these countries. Prior to the year 1882 some seven millions of Irish, Germans and Norwegians came to the United States. The influence of these people, as they spread throughout the country, was very great. Their ambitions included not so much those which led toward professional careers, as those which led toward industrial development. Agriculture received a new impetus, but while agriculture had up to this time been the chief occupation, it proportionately began to decline very rapidly in its relative position as compared with the manufacturing and commercial occupations. Beginning in the 80's and continuing until the outbreak of the Great War, the immigration came more largely from Italy, Greece, Roumania, Servia and other Mediterranean Sea countries, at the rate of about a million a year. These working people, as well as those who came previously into the country of new opportunity, began to send their children to the public high school.

The School of Democracy.

The million and one-half young people who are now attending the American high school are children of all of these different groups who make up what we call the citizenship of America. Their ambitions are no longer wholly professional, wholly industrial, wholly social, or wholly economic, but all these different ambitions and many others find a place in this melting pot, whose great function is to democratize, socialize, and give real purpose to this hoard of young people. The change in educational ideals has been brought about not only by new thinking about educational problems, but by a fundamental change in the composition of the group for whom our high school education exists. The change in occupations of the people as a whole, the breaking down of the boundary line between city life and rural life, the increased specialization in business, the clearer idea that education must bear a direct relation to the real opportunities of those who are educated, has caused us to re-define the purpose of the high school as a whole. The American public high school must provide the foundational training for all kinds of major activities in which both men and women are to be engaged. It is not expected to give the training that the artisan needs, but to give the general contacts which enable people to know the fundamental things that are involved in these leading occupations and to understand enough about the occupations to enable them to act intelligently with reference to them. The new high school must democratize its pupils. It must stimulate them to purposeful relations to the world's work. It must inform them about the common situations with which men deal, and must lead them to understand that knowledge is valuable in terms of its interpretation into the common affairs of life. The modern high school must open the opportunities for people of artistic and literary ability quite as truly as it does for those who expect to go into industrial vocations. The modern high school is really the opportunity school for the million and a half young people who attend it.

The Science Situation.

During the time when the public high school has grown to a position of such tremendous importance, science itself has had a notable career. The study of science has called

forth the abilities of some of the best men the world has produced, and their studies have added much to the world's sum of knowledge. The increasing division of science into narrower and more intensive branches has resulted in the production of more and more limited fields of endeavor, with larger research output, in science as a whole. It is to be hoped that this research work may increase, for upon the products of research much of the future of men depends. As the refinements of science have advanced there has been a tendency to introduce into the high school program each of the specialized subjects which have been found advantageous for mature students of science. Since one of the leading purposes of the American public high school is to democratize and to open opportunity to the great mass of young people who make up the high school population, the kind of science which has common interests to all must certainly be used in the high school program. Most of these pupils will not be special students of science. Most of them will encounter constantly the applications of science in their daily lives, from the moment that they rise in the morning until they go to sleep at night. Common life is full of science, but not the kind of science with which the specialist deals. The science of common life is interpreted by use of exactly the method which the specialist uses. We know enough now about the question of formal discipline to teach us that if the method of science is going to be useful in common life it must be learned in the common manifestations of science, and not in the special and unrelated refinements of science. We are facing an entirely different situation from that which was before us when the high school came into existence. We have an opportunity never presented in any other country for the democratic education of the larger part of the young people, who will be influential citizens. Since science has come to be the dominant note in modern life, science itself has the largest opportunity which it has ever held in the history of education. It will use that opportunity or not, determined by whether it faces frankly the problem of using the science of common affairs with which the masses of the people deal, rather than making the futile attempt of imposing upon people the special aspects of science which are properly of interest to special students.

GENERAL SCIENCE.

General Science, as an introductory course in the first year of our high schools, is the most promising of all the subjects which we have attempted in facing this new demand in science teaching.

What are the aims of General Science? Specifically stated, the following are some of the aims which General Science attempts to meet:

To help first-year pupils to a proper understanding and interest in the simpler and common phenomena of the environment as those things appear in the domestic, industrial and social situation with which the pupils come in contact.

To interpret the easily comprehended applications of the special sciences without any regard whatsoever to the place which these applications have in the specialized sciences. General Science makes no pretensions to teaching courses in any of the specialized sciences. It is a course in science for the pupils, not for science. It will undoubtedly be best for science in the long run.

General Science also aims to give the most valuable information about nature, and acquaintance with the methods of solving common problems with the thought that many of the pupils in the first year of the high school may not take any other science work, and need above all to have this point of view by means of which to interpret their environment.

The subject also enables many pupils to discover interests and choose vocations intelligently. It is an opportunity study. It considers science in education as being science for men and the improvement of the affairs with which men deal. But science can improve men and their affairs only as they use the methods and results of science in dealing with their affairs. Men are really educated through and by means of their work or they are not truly educated.

"As an attempt to get back nearer to the world in which the pupil lives, and away from a world which exists only for the scientist, the general science tendency has its justification."

John Dewey.

The High School Situation.

By John F. Woodhull, Teachers College, Columbia University.

Table showing the number of high schools in the United States at certain Periods:

Number of high schools	Year	Number of high schools	Year
1	1821	160	1870
2	1838	800	1880
3	1843	4158	1890
4	1847	8000	1907
40	1860	13071	1914

The above table shows the high school situation in a nutshell. Such phenomenal growth has of necessity produced conditions which are embarrassing.

Less than one hundred years ago, there was but one high school in the whole United States—The English High School in Boston. It was seventeen years before the second one was established—that was in Philadelphia. Five years later the third one was started in Providence and the fourth one came in Hartford in 1847—26 years after the first one. There were only 40 high schools in the United States in 1860, when some of us were beginning our education. When I began teaching in the high schools there were 800, and when the last report of the U. S. Commissioner of education was issued, there were 13,714. There are at this present date, probably 15,000. Buildings, equipment, and teaching force have not kept pace with that rapid increase in the number of schools. I say unhesitatingly that we are not as well off for rooms in which to teach, nor for equipment with which to teach, nor for teachers as we were 36 years ago. And this is but the necessary consequence of our astonishing growth.

When I began to teach, those 800 high schools were all little affairs, averaging perhaps 25 pupils each. There were not so many high school pupils in the whole country then as there are now in some single high schools. We have several high schools in New York City now that have more pupils than all the United States had when I began to teach. The pupils now number about 1,500,-

000 against say, four or five thousand in the whole country then. Think what the situation was like 36 years ago,—I recall it very distinctly: One was apt to have about 6 pupils in the chemistry class. We had laboratories then as we have now, and with 6 pupils—all American born—homogeneous—there was no reason why one should not do good teaching, at least the best he was capable of. If what some one has said be true, that the instruction which each pupil receives is inversely proportional to the number of pupils in a class, there can be no good teaching in the great high schools of today. When we reflect upon the large number of pupils that a teacher has to handle in each recitation, the large number of recitations each day, the care of apparatus in such large quantities, the necessity of ordering apparatus and supplies a whole year ahead of time and then rarely getting what one orders, the high school situation seems not only embarrassing but impossible. I recall that I secured during the years I taught in the high schools the privilege of buying directly from an appropriation whatever I needed, and I also had the privilege of planning the work—there was no syllabus, and no specific college requirement. It was a free hand for teaching individual pupils according to their needs.

When schools were small, a teacher was not all the while being supervised and super-supervised as at present. A teacher who knew his job was not then handicapped by the supervision of those who knew it not. This is a familiar feature of the great systems of today.

In those days when schools were small, politics did not enter. It was not worth while.

In those days we did not have a mongrel lot of pupils of all races not yet amalgamated. Only those got into the high schools who were fairly alike, intelligent persons, coming from intelligent families.

I do not think the tax-payer is slow in appreciating the value of the schools of today. One third of his taxes goes to the schools and the high schools get about one-fifth of the school tax. We are spending on the education of each high school pupil about five times as much yearly as we did thirty-six years ago but I believe we are giving them poorer instruction.

Another condition which may not be called embarrassing, but which I am sure we do not provide for adequately, is that the girls

predominate very largely over the boys, and we generally plan for the boys and do not think of the girls. The percentage of girls in our high schools is increasing. Ten years ago 48% of the pupils were boys and 52% girls. Today 44% are boys and 56% are girls. And when it comes to graduates, 40% of the graduating classes are boys and 60% are girls. The girls continue longer in the high schools and go to college in about equal numbers with the boys. When I was a college student, a college girl was a rare, not to say a unique thing, anywhere in the country. Almost all the colleges and universities now receive women as well as men. I can at this moment think of but four institutions that exclude women from candidacy for the undergraduate degrees. There are a large number of institutions, chiefly state universities, that have more women than men. The college women seem to be likely, in the near future to gain more prizes, such as election to PBK than the men. And if in the future as in the recent past, men in the community continue to drift into office work and women continue to drift into the control of practical affairs, it will soon be true that women will surpass men in their knowledge of physical science.

Another item in the high school situation, which is worthy of comment is the fact that out of 13,714 high schools, 10,547 are schools with only 3 teachers each. Very few high schools—three or four hundred—have specialized teachers of any particular science. In the face of this fact we have recently undertaken to equip teachers for the schools with that dense ignorance which characterizes specialists. This is doubtless a passing phase in secondary education.

Thirty-six years ago, the value of the books in the high school library was many times the value of the apparatus for science teaching. Now the figures are: 16 million dollars for scientific apparatus against six million volumes in the library. The "scientific apparatus" has not much to do with the interpretation of life and should give place to "commercial stuff", but the most disgraceful thing about the present situation is that the libraries do not contain anything useful. A lot of the high schools have in their libraries no books of science that any one reads. Meanwhile the community outside of the schools is reading much that should gain admission to the school libraries as a real aid to science instruction.

Not only have the schools within the last third of a century become overcrowded with pupils, but they are greatly overcrowded with subjects, the number having increased from half a dozen to more than two dozen in typical high schools.

The greatest cause for embarrassment however is our changing ideas concerning the purpose for teaching any subject. Three or four decades ago, if we wanted to indicate that a man had great knowledge we always attributed to him great powers of memory. President or professor so and so was a wonderfully bright man because he could remember the old students and call them by name whenever they came back to visit alma mater. Afterward it dawned upon us that a table waiter surpassed professors and presidents in the matter of memory. I remember one of the first shocks I got on that theory of education. Many years ago while attending a teachers convention at Saratoga several hundred of us passed into the hotel dining room and a big, burly negro took our hats without checking them. When we came out he astonished us by handing each his own hat. And I said, "What is the use of a college education?"

Some of the Pedagogy of General Science*

By HERBERT BROWNELL, Teachers College, The University of Nebraska.

Advocates of any subject seeking place in the course of study of secondary schools are very properly required to establish especial fitness and value for it, and a manifest superiority in its worth, in order to gain any hearing in its behalf. This of necessity encourages claims that experience has shown are not always fully realized when the subject is taught by those not specially prepared for it, and not enthusiastic in the kind of teaching necessary to its best results. It is quite likely that general science as a high school course will prove no exception to these experiences, however remarkable the results attained may be when in the hands of competent instructors. Teachers scarcely need to be reminded that the warrant for the use of any subject in a curriculum rests primarily in its educational values.

The claims here set forth in behalf of general science are peda-

* Given before the Science Association, State Normal School, Peru, Nebraska, Nov. 25, 1916.

gogical rather than academic, important as its subject-matter may be for the beginnings of secondary school science. One very proper claim to make in its behalf is that it fosters and in some considerable degree establishes with pupils an habitually "scientific attitude" toward their life problems as well as toward their school exercises. This contrasts sharply with teaching efforts that are chiefly if not exclusively for a mastery of the abstractions of scientific knowledge. The subject-matter in general science is primarily for general educational ends. Its classifications and groupings, its continuity and its unity, are accomplished through the interests and activities of the lives of those under instruction. The frame-work of instruction consists of the common experiences of youth rather than the generalizations and theories formulated by the master minds of science. Its requirements are in the field of the experiences and efforts of those under instruction. These requirements should constitute a natural sequence to what is already known by the pupils, and form an introduction to what they naturally desire to know next.

In order to keep in mind relative teaching values, the writer has found it of assistance to assume three fundamentals in the teaching process. It is his conviction that for their attainment, teachers should plan and strive assiduously. They may be briefly stated thus:

(1) A consistent stimulation and direction of pupils to the end that there be firmly established in them *a desire to know*—a life-long desire, dominating all life's activities regardless of occupation.

(2) Such instruction and training *in the procedure for mastery of knowledge* that pupils may not only learn efficiency in the school room, but are fitted *to solve the varied and complex problems of life.* It is possible to so arrange the requirements of the school life that they differ from experiences likely to be met in the later walks of life in degree rather than in kind.

(3) A gradual development in pupils of *confidence in themselves*—a belief in their own ability to do things. This self-confidence in order to be well-founded must be the natural outgrowth of numberless achievements in school requirements. To be suited to such use the difficulties to be mastered in school should have to do with the affairs of life and be real problems rather than artificial creations of the school room. They must not be, on the one hand, so difficult as to discourage, or on the other so easy in their de-

mands upon ambitious youth that they are not considered "worth while", and "a man's job." Such a confidence in one's power to accomplish, when combined with a desire to know, and a knowledge of how to proceed to satisfy this desire for knowledge, is productive both of an *initiative* and a *firmness of purpose* that is likely to accomplish the greater things of life as well as its minor undertakings.

The teaching procedure of general science accords so fully and satisfactorily with these cardinal principles of school instruction that claims in its behalf become more than the extravagant expressions of enthusiastic and over-confident teachers of elementary science. The common experiences of life become at once available in general science as a fund of knowledge of a typically concrete character. In these experiences there has already been established for those under instruction an interest in subject-matter of a most lively sort. A desire to know more becomes a natural outgrowth of conditions.

This knowledge already possessed, and that which is now for the first time to be imparted as instruction given in school, groups itself about centers that are so deeply rooted in the experiences of youth that these teachings will never be forgotten. New relationships, with their demands for insight and association, are possible with each added group of facts from the environment of childhood. A maximum of thought exercise with a minimum of abstractions is at once available for the instructor. Life interests are the centers of instruction, and the artificial barriers of specialized science are no longer teaching factors. Day by day, problem by problem, there may be experienced by the pupil that greatest of all joys—the sense of a power to achieve. Ability to do, and a readiness to undertake, go hand in hand in the work by very reason of its character, and occur naturally rather than as a forced and artificial training.

It is, however, upon the acquisition of those facts that have to do with each requirement of the course of instruction, and upon the discernment of what is vital in the association of these facts—upon all that is involved in what we call "study" in schools, that special stress is to be laid. Study is most assuredly a neglected art. And to have learned to study the problems of life aright, through the formation of effective school room study habits, to have gained both skill and confidence in the mastery of difficulties, is

surely an education worth while. It is education for citizenship and for better living.

The problem presented to the physician in every one of his patients, to the lawyer in every client, to the business man in every change of conditions affecting trade—the problems of the housewife, the farmer, the mechanic, and the financier, may differ widely in the nature of the facts involved, and in the procedure based upon such facts. But in the exercise of an ability to gather the facts bearing upon any of these situations; in the discrimination between facts that are of primary importance and those that need no consideration; in formulating a rational procedure in view of all known facts; and in the execution of any plan formulated, the intellectual powers are exercised in ways that are very much alike. The requirements of a general science course are easily shaped to yield a training in precisely these respects, and the skill and powers so gained actually "carry over" into the affairs of life outside the school.

The attitude of the scientist in any and all walks of life, and in all phases of its activities, goes a step further. Where, for any reason, there is failure to attain desired ends, the scientist reviews his interpretation of facts, remakes his working hypotheses, and again and again as may be necessary tests out his plans. Any study-training of the school room that establishes intellectual habits of this sort is an asset in any of the walks of life. Its value transcends the mere possession of information, howsoever valuable knowledge by itself may be. Indeed, we may properly question the value of any knowledge not available for use as needed.

With many of the branches taught in secondary schools the manner of instruction is fixed, and is scarcely to be changed. With general science there is possible a selection of subject-matter and a manner of instruction that makes its primary purpose in the curriculum actually as well as ostensibly pedagogical. This in no wise lessens the claims justly made for general science as a preparation for the differentiated sciences of the secondary school.

Any lesson preparation that is worthy of being called study requires an understanding of the nature of the difficulties to be mastered. It constitutes a "problem" to be solved. In a choice of topics suited for this purpose there is one of the most serious educational pitfalls of a general science course.

To assemble the facts bearing upon the topics (problems)

chosen; to cultivate a discrimination that takes into consideration only those facts which are essential; to see the various relationships between these facts, and to so organize (group) them as to unify and set forth their significance, is "study" to some purpose. Its very requirements provoke inquiry, and demand constructive thinking.

As seen by the writer, these features characterize the study of general science topics:—

(1) Books are necessary to furnish authoritative information. These are, however, but tools for the worker, and it is in their use as means to educational ends that the worker is to become skilled. It is what can be accomplished through the use of them and their contents, rather than ability to tell what is in them, that marks the real student. For the formation of right habits in the use of books there is required not only persistent effort on the part of the learner, but with most pupils the wise guidance and stimulation of effort on the part of an instructor.

(2) Any study of general science requires laboratory conveniences, and an outfit of simple apparatus and supplies. This makes possible first-hand information concerning common phenomena on the one hand, and opportunity for the verification of explanations of phenomena on the other. Experimental work may at all times illustrate the teachings of the instructor, but more often its great value will be in the demands it makes upon pupils, putting before them very strikingly and very clearly a challenge for the exercise of their knowledge and powers of understanding.

(3) But it is most important of all in the lesson preparation that the teacher take sufficient time—a whole class period if necessary—to get from the pupils what is severally known by them *as individuals* concerning the topic studied. And as these various additions to what is to become *class knowledge* are made, to so relate and unify it all, to so amplify and illuminate it, that it becomes both a means for appreciating further information and an incentive for acquiring it. Any moderate ability on the part of an instructor can accomplish remarkable results in these respects when there is kept in mind all the time the ends sought. On the other hand, the purpose is largely defeated where the teacher fails to organize through discussion what pupils already know. It is not enough for a teacher to be content with subject-matter wholly or largely wanting in association with the life interests of the pupils.

Whatever time is given over to a preliminary discussion of a topic in general science for these purposes, it is desired here to emphasize it as a procedure that constitutes lesson preparation, making out of it a "study period." The topics of a general science course lend themselves admirably to this end. At the same time, the connection between such discussions and simple experimental work by the pupils is so natural that the whole time given over to both may very properly be considered as a "laboratory hour."

The need of the pupil for assistance to understand more fully and to state more definitely what is being discussed, emphasizes the need and the right use of reference books as storehouses of information—a use of them that seeks definite information with an expenditure of the least possible time and effort. The hopeless mental state that results from pouring over material in books that answers no need that has been experienced by the learner, however important this material may have been to the author in the development of some discussion, naturally causes in the learner mental aversion for the subject or mental dyspepsia.

This laboratory time when used as a "study hour" is a procedure for meeting and mastering the "problems of life" that arise in the discussion of general science topics. Variety of treatment becomes necessary as topics change, but the intellectual processes and activities are at all times under the control of the instructor. Lesson preparations of this character provide something very definite and very complete upon which to "recite" later. Further instruction upon a topic studied after this manner, whether to amplify it or to apply the teachings, will find the pupils prepared to receive it. But whatever the topic, and whatever the value of the information grouped in connection with it, *it is the study-training* that general science offers opportunities unrivalled among the subjects for beginners in high school branches. To make its teachings book readings and recitations only, and its experiments merely illustrative of text narrative, is to sacrifice very largely its teaching possibilities.

Bibliography of General Science

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The large number of inquiries regarding the literature of general science indicates a widespread interest in the subject. There has been no guide to the growing literature of the subject excepting occasional references by one author to the papers of another. It is in the hope of assisting to make the literature of general science more readily available to students of the movement that the annexed list of citations is published.

The compiler has attempted to include in the list every paper dealing with the general science movement and those cited by writers on general science to the end of 1916. It is doubtless true, however, that many papers which have received only local publication, as in state teachers' magazines, have not come to his attention. It is equally possible that papers which have been published in widely circulated journals and are well known to the compiler may have been inadvertently omitted. Corrections and additions will be welcomed and incorporated in a list of additional citations to be published later.

Citations have been verified so far as possible, but in some cases the original publication was not available. Notice of errors will be appreciated.

A number of papers which are concerned primarily with collateral movements in other subjects have been included on account of their bearing upon the general science movement. It is believed to be important for the student of the general science movement to become familiar with efforts at unification of other subjects, as mathematics.

No books are included in this bibliography, whether textbooks on general science or general educational works in which general science may be discussed. Neither of these sources should be neglected, but they are not within the scope of the present paper.

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Abbreviations of Magazine Titles used:
G. S. Qr., General Science Quarterly.
S. Sci., School Science and Mathematics.
S. & Soc., School and Society.
S. Rev., School Review.
Ed. Rev., Educational Review.
N. S. Rev., Nature Study Review.

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Some Phases of the General Science Problem

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The reconstruction of the courses in first-year science is in a state of "becoming." There is no doubt that there is a decided need for a change and I believe that the work is going on in the right direction, despite the complaints and the poor evidence that is brought out. There is no doubt about the fact that there are some miserable attempts at general science teaching and science reconstruction as a whole, but that must be expected until the situation gets better established and a somewhat uniform conclusion is derived in the matter of the problem of text-books, teachers, subject matter, aims, ideals, etc.

One can find, as he looks over the various articles, a great number of reasons for putting in a general science course in the first year of the high school. There is also a wide difference of opinions expressed. Some of the reasons as brought out in the various published articles are:—

(1) Thirty per cent of the high school students drop out before the beginning of the second year. Many of these have had no training in scientific method or facts, not even in physiology, and the general science course will at least give that.

(2) If the student does not continue in school, and has had a course in general science, the pupil will be able to do successful work more ably in the more advanced sciences, such as physics, chemistry, and geology, that come in the later years.

(3) By having been introduced to science by means of such a course, the pupil will be able to make a wise selection in the courses that come later in the high school course.

(4) Such a course gives the pupil and the teacher a splendid opportunity to discover the capacities of the child, which is one of the coming duties of the school.

(5) It should give the student a knowledge of simple scientific facts.

(6) From a psychological viewpoint the more important gain from such a course is the training in scientific method that is necessary to a good understanding of one's environment that will help him adjust himself better to the environment about him.

(7) It gives a background which should be closely connected

with the more advanced scientific work, which is just as pedagogical as the ground-work in Latin, English, or Mathematics.

Statement of Some of the Conditions that Have Brought About this Problem and Some of the Things that Have to be Considered.

Early History of Science Development. This is the scientific age and the introduction of science is relatively, or rather historically, a new or recent adventure. Altho industry can be traced to the early days and in early history one reads about the skilled workmen in the Guild Period, yet if one studies the situation he will find that there is no early co-ordination between science and industry. Science began by asking for explanations in a large way. In the time of the guilds the men were highly skilled but when they would talk about science they would talk about such things as the immortality of the soul, not thinking about objects about them. In fact, there was the widest breach between science and industry. Science became intellectual from a social viewpoint. In the early days when the tribes were isolated, each had its own explanations for the things that happened about them (such as the Saraha desert being scorched by the sun at one time), and when these tribes later began to live in groups they found that each tribe had a different explanation and the idea about the gods or phenomena of nature, etc. They came to the period then of uncertainty and skepticism, which was a necessary step in building up the scientific attitude.

As soon as we come to a place where we realize the life of the other fellow, we begin to see how narrow we are and have been.

Later Development. The scientific attitude is one of the later attitudes that one can come to. The child is not interested in the abstract fact but the reaction that takes place within the individual. We are not primarily scientific or critical. We jump in and speculate, so with primitive man. We patch up something that comes up in domestic life that needs repairs and when we cannot fix it by chance we call on some one to come and help us fix it, without analyzing the thing to see what really is the trouble. The attitude of focusing everything to scientific explanation is a recent achievement, especially in America. The German Committee report after visiting the World's fair held in St. Louis explains

the situation as it appears to be in America—"We have nothing to fear of Americans,—they have no finished products,—they do not know how to apply science to their industries."

General Science Problem. So we haven't a right to believe that the child has the power of focusing his energies with a scientific attitude until the time is ripe for the development of the critical attitude. We sometimes think that the child is scientific because he asks for some explanation. This critical attitude should be developed the latter part of the high school age. This points out the complexity of the science problem in the high school age. The intellectual soil is not right for sowing scientific attitude until you can get the critical attitude. This time is during the adolescent period. This is the period when the general science problem comes in and is to solve the situation.

Man's mastery over the forces of nature and the wonderful achievements of science has recast all of the activities of daily life, completely changing home conditions, the school and its surroundings, every phase in the country, town, and city life; methods of heating, lighting, ventilating, and sanitation; of obtaining food and clothing have changed. The social significance of science in present day life gives it an important place as a subject in our public school curriculum.

The science work in American educational institutions all the way through is designed and planned to furnish a direct path for the training of research workers. This is necessary, but it is also necessary that we do not lose sight of the fact that the needs of the masses of young folk, who are preparing for the ordinary activities of life, receive due consideration.

The percentage of students studying the older sciences in our public schools is on the decline and has been on the decline for the past twenty-five years. (Commissioner of Education Report, 1910 Vol. II. 1139) What is the trouble? What is the remedy?

The trouble seems to be over-specialization. Something has to be done, and the general science movement is a part of the plan to straighten out the science situation in the secondary schools.

Present Status of General Science. During the year 1913-1914 about 300 schools in the United States attacked the problem of revising the science courses by offering general science with many others contemplating doing so. Practically all of these schools were giving but one year of general science while at the present

day some are giving two years of general science and in a few years more will follow.

No generally satisfactory text book has made its appearance, although one or two late ones come nearer to the type that is needed than at first. The difficulty with the text book problem is that for the most part the books are written by university men who are interested primarily in some one of the particular sciences and he writes his book centered around this one subject. It is necessary that the text present a well organized course, as they do in the special sciences, until there is available a supply of teachers who are especially trained to teach the subject.

Subject Matter. The subject matter should be carefully selected and be closely related to the needs of the pupil and common things of his life,—things he sees and handles. It should seek to give him a body of information of significant things, and care should be emphasized in the selection of the matter, according to the past experiences of the child and what he is interested in. If general science is to be of educational value, it must consist of well organized units of instruction. They must be definite and as well organized as are the units of special science. They will be, however, units of practical or applied science instead of units of theoretical science. The course should have unity and logical development taking the pupils in any field of science necessary that is adapted to the adolescent mind, and it must appear as worth-while to the pupil. It should train in scientific thinking and deal with material with which the pupil is already somewhat familiar, starting from the known to the related unknown. It should give the pupil control of his environment and an appreciation of the significance of science in the modern world.

Difficulties. It can be easily seen that a difficulty arises in attempting to formulate a systematic course based on these fundamental principles because the experiences of the children in various parts of the continent and even in the same city are so different. Then again it would be harmful to emphasize any one of the sciences to too great an extent and it would be disastrous to give the pupils the impressions that they had taken the various science courses in the one course.

Psychological Point of View. In the last analysis looking at the problem from a psychological point of view, it is not so important whether one is teaching biology, physics, or general sci-

ence to these students, as it is important that the scientific attitude is aroused in these adolescents.

General science doesn't guarantee to correct the mistakes of poor teaching. Furthermore we must not expect that these pupils should have an abundance of scientific information that can be used immediately. If we taught a little French, Spanish, Latin, and German in one year in the same course, we wouldn't expect the child to have much language power of interpretation. So with science. We cannot teach science and scientific attitude in the limited time that one year allows. So it seems to me that it resolves itself to the point where we must teach the one phase, namely—the scientific attitude, which should be done not by a little physics and a little chemistry, etc., but by a well organized plan after the material has been carefully selected.

It is very noticeable that the teaching situation in agriculture and domestic science and elementary science in both the grades and high school has changed greatly. There has been an enormous advancement in spite of the fact that the enrollment in the old-line sciences, such as physics, chemistry, physical geography is and has been for some time on the decline.

Studies of children's interest point out that children in the grades and the early high school age are not particularly interested in nature material from the utilitarian point of view. They are interested in the usefulness of such things from the child's point of view,—its usefulness in play,—and not from the so called practical point of view of the adult. The reason for the vim with which children take to these elementary sciences is one of methods of presentation and reorganization rather than content, as most of the subject matter is the same as was previously presented, botany, zoology, etc.—but it is now presented in a concrete form, which tends to bring out conscious order of the chaotic environment of the child.

Science in itself is an impartial presentation of facts. It doesn't stir the emotions or will of the child, until is added to these facts the human relations; which are numerous even within the child's experience. The knowledge of nature's wonderment is important but more important in the introductory science is the training involved in its presentation. The elementary study proceeds from the superficial familiarity with many phases to a more

intense study of certain typical aspects, starting with the environment as a whole.

This approach of intellectual appreciation and apprehension of natural phenomena through the study of concrete situations or projects is in accord with the way the child's mind works. In studying the thinking processes of children, one realized that the natural mode of attack is to group the situation as a whole. Then to comprehend its parts, and later the relationships to each other. Then a second situation is comprehended and analyzed and after many of such experiences and analysis the individual child begins to put together general ideas and arrives at scientific principles.

The scientific organization of subject matter and the working out of the laws and fundamental principles is a later stage in the historical development as has been pointed out earlier and therefore should come at a later stage in the intellectual development of the individual. Children begin to reason moderately early, but reason efficiently only with concrete materials. The abstraction phases in the mental development come later.

Psychologists of the adolescent period tell us that there is a time in the child's mental growth when there is a "coming back" to, or better still, a "going back" to juvenile activity in the growth of sensory and motor brain areas and of the sensor-motor association areas in early adolescence. There would be expected then a renewal of interest in things in a definite situation or in concrete problems and projects. In so far as that is true there is good ground for a renewal of nature study methods in the early years of the high school period. There also comes at the adolescent period marked social changes, that of coming out of the conscious enclosure the child has put himself after finding that society had become critical of him in years previous to the adolescent period. This new interest and coming back into society would cause one to feel that first year science work in the high school should be organized somewhat in nature study lines, in so far at least, as the presentation of matter in concrete situations and projects is concerned and should look toward organization more on the basis of social and also economical principles than is done in the elementary science work in the grade. (There is also this interest manifested in economic conditions when the child "comes out" of the enclosure period.)

Children from 12 to 15 years of age come nearer to all persons

to using the method of great masters of science, and practice the most real research. "The native and unspoiled attitude of childhood marked by ardent curiosity, fertile imagination, and love of experimental inquiry, is near, very near to the attitude of the scientific mind."* So it resolves itself in a complicated problem of teaching, handling the child in such a way so as not to spoil this attitude and at the same time work it and train it so it may become fruitful in the right direction. This same point is brought out in Mr. Ayer's statement found in the survey report of Springfield schools wherein he says, "The greatest problem that the schools are facing is the lack of intimate relationship between the work of the schools and the work of the world. Such work must be real instead of artificial, where pupils are learning something real that has an object behind and a result to come,—they are energetic,—when they listen to, or watch, or read something that is to them artificial they are apathetic. In all of these characteristics the children in our schools closely resemble us adults."

So the science studies must be organized to take care of the child according to his natural mental development and the movement of general science is a protest against the present regime of unorganized subject matter and calls for purpose of instruction to introduce a "psychological organization" which means that the organization of subject matter must be made around the knowledge of the pupil, not around the teacher or the syllabus maker. We have to build on the interests and experiences of the individual, otherwise we are hanging our buildings or hypothetical foundation in mid air.

There are a large number of these children, some dwelling in cities who are stimulated by artificial noises, sights, mechanisms and pictures; others who live in villages or the country, or town where they are amidst a wealth of natural phenomena. Again, they are living in an age and country in which, relatively speaking, a complete explanation of almost unaccountable phenomena has been attained. We must comprehend, describe and classify the wealth of natural phenomena at our disposal and of practical application of science which are to contribute to the methods and means of the study of the general science problem.

We must also study the native capacities, acquired interests, and the powers and probable needs and opportunities of the children

* John Dewey.

whom we are to teach. We must define and test the aims set forth—To gain knowledge of facts, scientific attitude, sense of substantial achievement at the end of the year, satisfaction of curiosity, discovery of cause, realization of use, the rending of practical service, etc. Interest is the great educational magnet which means that the teacher must teach the pupil and not the subject. One of the chief aims in science surely must be the creation of an interest in the daily phenomena surrounding the child. This early introduction to science must handle the situation in such a way that the scientific attitude is brought out rather than the accumulation of a *"bunch"* of facts. It should be handled by a few large topics carried in a systematic way entering whatever field of science it will within the powers and experiences of the child, being elementary and yet significant to the child, and based upon the characteristics of the child and not the subject matter. Some of these characteristics that have to be taken into consideration in handling these youngsters are—that their interest is somewhat superficial spreading over a large area, and not going very deeply. They demand quick returns or their attention will flag. They are optimistic as a rule at this age,—they have studied books all their school days, so if they are to be interested and the course in general science adapted to them, it must embrace more than one line of interest and must include and explain the every-day phenomena of the pupils which it is to serve.

One of the big problems will be to get competent, sympathetic teachers. It is not necessary for a teacher of general science to be a specialist in all the sciences or in any one, but he ought to have some training in each and a large understanding of the child and its peculiar developments. If the teacher is one who is absorbed in one science, the problem is a serious one because he is apt to lose sight of his pupils and be interested only in the less important phases of the situation—namely, the science.

The growth of specialization in present civilization is one of the drawbacks of the present scientific age. It makes or is very likely to make the one absorbed in his special science extremely narrow, which is the source of one of the gravest problems in the present secondary school.

There is need of a general curriculum of science courses so related that there is a continuation of the mental and scientific development based on the introduction of new and more difficult

phases as the mind is further along the field, unifying the experience of the child through the development of systems of ideas. Problems in science must be intellectually apprehended since only when the problems are understood will the science develop. Science courses, the same as mathematics courses in the secondary school, lack the progression necessary for the right development of the mental activities in the science. The way it is arranged at the present time the student studies a little botany and physiography, and then a little physics and chemistry and begins all over in each of these courses with simple problems and simple methods of scientific methods at the beginning, each course beginning as though nothing had ever been done to train the pupil in scientific methods. As a matter of fact the classes are at present mixed, putting in second, third, or even fourth year courses, students who have had three, two, one and no training in science courses previous. The student, in such an arrangement can never realize that there are different degrees of complexity in reasoning. He realizes very slowly, if at all, that the first stage of science study is to collect a few simple facts with a certain degree of accuracy,—the second stage to try and develop some sort of a general principle using the observations made by him,—the third stage, that of verifying the conclusions. What is needed is a realization of the mental processes which represent progress within the science. We need a list of all the different kinds of mental activities that students are called upon to go through in each science,—that there is always some memory work which is necessary for comparison and reason, which comes later,—and the student needs to realize that there is a sequence from memory to reason and a sequence from the simpler stages of scientific mental activity to the later stages.

The period of adolescence which is also the period where individual differences begin to show up, is the time when it is necessary to give the student general courses in all the major fields of human experience. It is a period of general training which will be followed by specialization later on.

General Science for the First Year of the High School *

F. W. Berninghausen, Supt. of Schools, Beaman, Iowa.

The specific sciences, favored by so many educators, do not meet the needs of the ninth grades better than general science because such sciences as taught in secondary schools are defective; first, in regard to text books; second, in regard to the method of teaching; and third, in regard to aim.

High school science text books as a rule are not written by high school educators. We find that by far the greater number of such books are written by specialists in some particular science. While this feature has its strong points, it also has its defects. Scientifically and technically texts written by experts are without fault, pedagogically such texts are often wrong, especially when placed in the hands of the ninth grade pupil instead of mature college people. Let me illustrate my point; we pick up a botany that a botanist has written for secondary school use. All brother botanists proclaim it perfect and recommend it strongly for the place for which it is intended. Next in order is the adoption of this text by a high school because of its authority, and not because it fits the particular need of the one who is to study it.

The proof of a pudding is the eating thereof, and if we apply this principle to the case in hand we are likely to be disappointed. After a start has been made so that the pupil has had a chance to be introduced to his new subject the instructor so often hears this fine text called "Punk" by the boy or girl that starts out on the science. Of course the teacher is horrified; Young America is using his prerogative of free speech and consternation reigns supreme and if asked what is wrong with the book Johnny replies, "I don't see why they can't write a book a feller can read and understand. I read this twice and there are so many big words in it that I don't seem to get head nor tail out of it." If the teacher is wise he will slow up on assignments and give a drill on words and definitions, if unwise he comes to the conclusion that Johnny can never become a scientist anyhow so why bother to explain away the difficulty. In an actual investigation provoked by such a

* Abstract of paper presented before the Biology Section of I. S. T. A. in Des Moines, 1916.

reception it was found that this text contained about 400 words in a glossary appended, and it is only fair to assume that the author used an additional 100 words unfamiliar to the student, making a total of 500 new words for the pupil. The content of the subject matter covered 340 fairly large pages. Now then in one semester this subject called for the learning, defining and assimilation of almost all of these words, and in addition the facts about the science, plus laboratory work twice a week.

Botany out of such a text is called a recognized high school science. It is more than just merely science, it is language; and in this case the most of it was foreign language. To make the comparison clear let me state that when the German teacher was asked to report the new words her class in first year work took up in one semester she found by actual count that it amounted to a little over 500. Because all of these words were German, we call this subject language, in the case of botany we call it science.

Further the content of the recognized science text book invariably shows the predominating influence of the college science, to the exclusion of the common terms and phenomena with which the average boy and girl is familiar. Instead of placing emphasis upon the practical side of the subject the abstract and theoretical is counted most important. Prof. Timbie of Boston makes the statement that this is the common experience in such texts. He further states that: "Text book writers should take the hint from the primary schools, and not despise material with which the boy is already familiar. Phenomena which he can comprehend, and explanations which appeal to his common sense. Let us leave our abstractions and inject subject matter into the course which will contain the leading elements."

Taking up my second point, that high school science is wrong as to method of teaching. All science does not fall under this category as it is now taught, but I do wish to state that physiography, physiology and botany, as taught in the average small high school, is about 90% pure memory work and not scientific work. To get a passing grade in such subjects, a pupil must be ready with answers to the questions put to him, and these questions are based on text book material almost entirely. Let me ask: "Is it scientific to have high school pupils study the text, recite from the text material, cite illustrations of phenomena from the text, and then *sometimes* end up with experiments?" If it is, then high

school science is being taught in the right manner. If this is not science, it fails, insofar as these things are factors. Why would it not be wise to adopt the inductive method in teaching secondary science?

My third point deals with the aim of high school science. The aim of the high school, originally, was that it must prepare the student for college entrance. This aim has not been changed materially, if we except from our course general science and the vocational subjects. In general science and in vocational subjects, the high school is not a secondary school, but a leader, a finisher of the boys and the girls who go to work instead of going to college. The high school has a double task to perform in the way of instruction.

Right here is the parting of the roads to right and wrong education. The college once dictated—"Thou shalt not give general science and vocational subjects." But the high school kept on fulfilling its double mission, until in the case of the vocational subjects the bars were let down and high school credits in these are accepted by the higher institutions. General science is an exception to this, for the reason that it is pure high school science and does not smack too plainly of college science.

Now, in general, let me state that instead of a wide open door through which to enter to science, the high school pupil feels that the door is but half open. Instead of going from the known to the unknown by easy steps, he soon comes to the conclusion that science is one-half guess work on his part, and one-half an endeavor to learn data and learn a new language. The guess work is necessitated in the problems he may be forced to work out by the forms given in the text. He can work the problems easy enough in many cases, but he readily admits that he does not see the reason "why". This is the place in which specific science falls down. The common every-day phenomena is so little understood that almost nothing carries over. But, you say, that in the majority of cases this is not so. All right, for argument's sake we will accept your statement. If your statement is true, why is it that the average college girl graduate, who has studied some science in the high school and some science in the college, and who is now teaching in the high school, most always gives a flat refusal or objects strenuously to teaching high school science. The usual answer is, in such a case: "I did the work; I got through all right; but I never

understood what I was doing. I just can't teach that subject." I have been told by these same teachers that their instructors were simply great in their line of work, but were also so specialized that they failed to get the attitude and viewpoint of their pupils.

Authoritative text books are necessary, and their use is to be commended; but why not get this new science material over to the ninth grade pupil in as natural, in as common every-day language as is possible. Here lies an immense stumbling block in the way of the new scientist. Here is the cause for so much distaste to science. It is not so much the material oftentimes that can be objected to, as it is the manner in which that material is presented. Ladies and gentlemen: We do not object to sciences as they are now offered in the high school, but we do object to the elimination of general science, for the reason that it does not conform to the established kind of science. To object to general science on such a score is to object to something because it is expressed in common language. It is to object to common science because it is of interest to all, and of use to all. It is to object to simplicity, directness, and naturalness. To rule out general science in Iowa at this time, is to say to more than 250 high schools of the state that they are wrong in curricula content. To rule out general science for any reason, is to take a backward step. Progress in education must of necessity be very slow, but nevertheless we progress. It has not been so very long ago that the subject of agriculture was not called a science, no matter where taught. At present it is a recognized science in all institutions of learning. Manual training and domestic science are now taught in practically all secondary schools, and colleges now recognize such work.

Human nature is much the same among all classes of people. College instructors in science departments, are usually loth to admit new science subjects. This is but natural. Further: high school instructors are just as loth to admit new subjects to the already crowded curricula—more nature. But when a subject such as general science, a science of common things, presented in common language, and as common sense dictates, presents itself, it is tried out by secondary educators. It has been tried out and found worth while.

In summary, let me reiterate that recognized sciences, as taught in our secondary schools, are wrong in text books, because these texts are too technical, contain too much material, and are not writ-

ten with the idea of teaching pure high school science. Second: That the methods of teaching recognized science in the schools, is not the inductive method, hence has a weakness. And, third: That the aim of science in the high school, is not broad enough, is not big enough to meet our present need. We do not wish to make specialists and experts out of the majority of high school people, but we do wish to fit them as best can be for all the isuses of life.

"The Project" in Agricultural Education

By F. E. Heald, Specialist in Agricultural Education, States Relations Service, U. S. Department of Agriculture.

The term *project* has within recent years gained a recognized standing in educational and scientific circles in at least the following particulars which contain several identical points:

1. The *home project* and the *class project* in agriculture, home economics and some science work as adopted and administered in Massachusetts, New York, and other States.

2. The *club project* as used in the co-operative work of the Federal and State forces, in which a season's work along a given line is called a project.

3. The *project* prepared by the scientific investigators in the State experiment stations covering a definite line of investigation, and approved at the Office of Experiment Stations of the U. S. Department of Agriculture.

4. The *extension project* prepared in the States and approved in a similar way in the States Relations Service of the U. S. Department of Agriculture.

Certain terms have grown to have such an established place that it is best not to add confusion by making applications of another nature, although the derivation and dictionary definition would warrant the new use of the term.

The division of Agricultural Instruction has frequent occasion to use the term project as applied to school instruction, and as it does not assume the authority to impose definitions, it has compiled in brief form the requirements which seem more or less common where projects have received serious consideration.

Such a definition which was first printed in U. S. Department

of Agriculture Bulletin No. 281 as applying to home projects, and further developed in Department Bulletin 346, reads as follows:

"The term 'home project' applied to instruction in elementary and secondary agriculture, includes each of the following requisites: (1) There must be a plan for work at home covering a season more or less extended. (2) it must be a part of the instruction in agriculture of the school, (3) there must be a problem more or less new to the pupil, (4) the parents and pupil should agree with the teacher upon the plan, (5) some competent person must supervise the home work, (6) detailed records of time, method, cost, and income must be honestly kept, and (7) a written report based on the record must be submitted to the teacher."

This agrees with the other accepted applications of the term project in the essentials which are briefly described here.

1. The plan must have an aim which is in accord with the general scheme of work, in which the pupil has an interest at the outset and in which there is some problem more or less new. The person who approves the project at the outset should have some broader view of the applications and should shape the general plan accordingly.

2. The project should involve principles already studied or which are studied concurrently with the practice. The discoveries of others should be found out, either by observation or by reference study, and records of these should be compiled. Problems, practicums, demonstrations, and occasional experiments may be necessary as a part of the project. These in themselves may be within the dictionary definition of the term project but we have already these other terms in the vocabulary of education. The exact line of demarcation between a short project and a longer practicum may as well be left undecided, but the tendency to give to everything which may be "projected" or planned the name *project* is unnecessarily confusing.

3. The records and reports covering each of the steps or processes with final conclusions or results should be preserved.

All of these points will apply, whether the project is for an individual or a group; at school, at home, or elsewhere in the community. To start with a definite aim, to do certain correlated lines of work covering a fairly extensive field or period of time, and to bring together everything bearing on the main aim are essential

points in a project. A specimen project here given may be developed either in agriculture or correlated sciences.

A Project—The Profit from a Dairy Cow.

A sample outline without detail.

Project Divisions.	*Items Involved.*	*Correlated Material.*
Milk two or more cows for one month or more.	Sources of milk. Sanitary milking. Care of cows.	Sediment test of milk. Care of milk in the home.
Weigh milk at each milking and record on sheet in stable. Total each week and each month.	Proper use of the spring balance. Factors influencing variations in milk flow.	Daily, weekly, and monthly records of notable cows. Averages for herds and for the State.
Take samples of milk morning and evening twice each week. Observe cautions.	Natural separation of milk. Specific gravity of each part.	Emulsions and their peculiarities.
(Run separator or cool and store the milk as required). Test each cow's milk separately for butter fat at least every two weeks at first, monthly later.	Commercial disposal of milk; making of milk products. Principles of centrifugal action. Sulphuric acid in this connection. Basis of computations.	Specific gravity of liquids. Bacteria in milk. Spread of disease by milk. Applications of centrifuge, drying machine, etc. Acids. Neutralizing.
Compute total butter-fat per cow. Compute total income at the market prices, by the day, week and month.	Composition of milk. Percentage of each part. State or city standards for total solids; for butter-fat.	Milk as food. Value of each part. Relative value compared to other foods.
From weight of cow and daily production, compute a ration and vary until success is apparent.	Digestible nutrients of local feeds. Balancing a ration. Economical rations of home-grown feeds.	Human food. Sources of protein. Clover and other legumes.
Compute cost of rations, cost of care. Credit cow with butter-fat, skim-milk, manure, etc., and find net income for week and month and whole period.	Manurial value of feeds.	Cost of production of other products of domestic animals. Factors included. Labor of horse, eggs, beef, wool, etc.
Compare cows. Compare each with the points in score cards for judging.	Judging dairy cows. Observation trips. Famous cattle.	Types and breeds of cows.

Such an outline may be modified to meet local and personal circumstances. In some schools the main project would be handled by the agricultural course and the related science by the general science course. In another school the project itself might be a part of the science work.

A project might be largely investigational as in the case of sewage disposal or ventilating systems, but the greater the personal activity the relatively greater the value which may be expected.

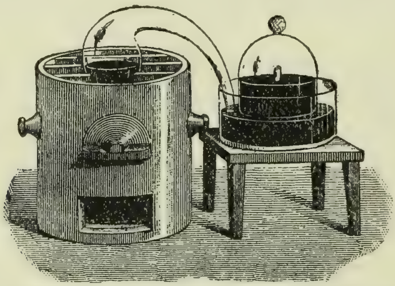
Whether the application is made to projects in science, agriculture, community civics, or any other subject, it would seem desirable to obtain uniformity for the sake of clearness. The interpretation here given is that used by several State boards in administering the school systems and seems quite generally accepted in sections which have developed such methods of instruction.

"The best part of all human knowledge has come by exact and studied observation made through the senses of sight, hearing, taste, smell and touch. The most important part of education has always been the training of the senses through which that best part of knowledge comes. This training has two precise results in the individual, besides the faculty of accurate observation—one the acquisition of some sort of skill; the other the habit of careful reflection and measured reasoning which results in precise statement and record. . . . Sciences should be taught in the most concrete manner possible—that is, in laboratories, with ample experimenting done by the individual pupil with his own eyes and hands, and in the field through the pupil's own observation, guided by expert leaders." *Charles W. Eliot.*

The First Analysis of Air

Being an account of Lavoisier's celebrated experiment, translated from his own description of it.

"Taking a vessel, or a long-necked tube, with a bell or globe at its extremity, containing about thirty-six cubic inches, I bent it so as to place it in the furnace while the extreme end of the neck was under a glass cover, which was placed in a basin of mercury. Into this vessel I poured four ounces of very pure mercury; and then, by means of a siphon, I raised the mercury to about three-quarters the height of the glass cover, and marked the level by gumming on a strip of paper. I then lighted the fire in the furnace, and kept it up incessantly for twelve days, the mercury being just sufficiently heated to boil. At the expiration of the second day, small red particles formed upon the surface of the mercury, and increased in size and number for the next four or five days, when they became



Apparatus used by Lavoisier in analyzing air

stationary. At the end of the twelve days, seeing that the calcination of the mercury made no further progress, I let out the fire and set the vessels to cool. The volume of air contained in the body and neck of the vessel before the operation was fifty cubic inches; and this was reduced by evaporation to forty-two or forty-three. On the other hand, I found, upon carefully collecting the red particles out of the melted mercury, that their weight was about forty-five grains. The air which remained after this operation, and which had lost a sixth of its volume by the calcination of the mercury, was no longer fit for respiration or combustion, as animals placed in it died at once, and a candle was extinguished as if it had been plunged in water. Taking the forty-five grains of red particles, and placing them in a small glass vessel, to which was adapted an apparatus for receiving the liquids and aëriform bodies which might become separated, and having lighted the fire in the furnace, I observed that the more the red matter became heated, the deeper

became its color. When the vessel approached incandescence, the red matter commenced to become smaller, and in a few minutes had quite disappeared; and at the same time forty-one and a half grains of mercury became condensed in the small receiver, and from seven to eight cubic inches of an elastic fluid, better adapted than the air of the atmosphere to supply the respiration of animals and combustion, passed under the glass cover. From the consideration of this experiment, we see that the mercury, while it is being calcined, absorbs the only portion of the air fit for respiration, or, to speak more correctly, the base of this portion; and the rest of the air which remains is unable to support combustion or undergo respiration. Atmospheric air is, therefore, composed of two elastic fluids of different, and even opposite, natures."

It is not practical to reproduce the first part of Lavoisier's experiments before a class, but an account of it is interesting to the pupils and although the two gases were not named when Lavoisier performed the experiments, pupils will readily see that they correspond to oxygen and nitrogen.

A simple experiment, suitable for seventh and eighth grades, which shows roughly the relative volumes of oxygen and nitrogen in the air is that in which a burning candle, floating on a flat cork in water, is covered with a bottle whose mouth is pressed down into the water. After the oxygen is consumed the candle goes out and water will rise in the bottle to take the place of the consumed oxygen. Close the mouth of the bottle while under water and remove, placing it mouth up. Test the nitrogen with a burning taper to show that it does not support combustion.

The second of Lavoisier's experiments, that of liberating oxygen and mercury from the red powder, mercuric oxide, may profitably be performed as a demonstation or even done individually by the pupils. Place about one-fourth a teaspoonful of the red oxide in a test tube. Hold the tube nearly horizontal and heat only that part of the tube about the red powder in order that the other part of the tube may be cold enough to condense the mercury. When there is a good evolution of oxygen, test with a glowing wood splint to show that it will cause the splint to burst into flame. Continue the heating until a good mercury mirror is seen on the cool part of the tube. This may be scraped off and identified as mercury.

W. G. WHITMAN.

Some Problems of Elementary Science*

By ALBERT EARLEY, Principal of the North Plainfield High School, New Jersey.

In preparing for this discussion today, I was surprised to find that elementary science was discussed by the N. E. A. as far back as 1869; that some Illinois schools have been teaching elementary science for sixteen years. In my ignorance I had supposed that the subject was of more recent origin. However, I believe that it has come into the limelight within the last four or five years. I have been reading School Science and Mathematics since 1908 and until about 1912 there were very few, if any, articles on elementary science. That the interest is becoming keener is evidenced by the appearance of a new journal, "General Science Quarterly", the first number of which has just been issued.

One problem which may confront some schools is to show the need for elementary science. Can you explain to your patrons why another subject has been added to the curricula and why this particular one has been chosen? As science teachers, we would strenuously defend the proposition that at least one science must enter into the scheme of education for every intelligent person. In this we would be backed by Dr. Eliot, who deplores the fact that so many of our professional men lack a scientific education. He points out as an element of weakness in our educational scheme, the fact that so many men otherwise well educated, have never used an instrument of precision. Some subjects will develop mainly the imagination; some the memory, but the sciences stand preeminent in developing the powers of observation, in encouraging an inquiring mind, and in training the reasoning powers. Since some science is necessary, the next question is, what science shall it be and when shall it be given?

Our Assistant Commissioner, Mr. Meredith, states that about fifty per cent of all high school students are in the first year, hence, if the majority of our students are to get any science, it must not be later than the freshman year. I presume that we are all of the same opinion on this point. The reports of the U. S. Commissioner of Education show that at the present rate of decrease, science will have disappeared from all schools in the year 1960. The

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* Paper presented at a meeting of the Elementary Science Section of the N. J. State Science Teachers Association, Nov., 1916.

decrease in the number of students studying science, as shown in the same report, indicates that something is wrong. If specialized science is losing its grip, let us try general science. Furthermore, physics and chemistry are highly specialized and are, therefore, not adapted to first year students, but elementary science is.

Another problem is what should be the object of a course in elementary science? On this point there is no agreement. Some say that the purpose is to lay a firm foundation for further work in science and to help the student who finds mathematics difficult. Dr. Eliot has said that the most important aim of education is to furnish opportunities for self-discovery. No other subject in the high school can possibly rival elementary science in furnishing opportunities for the student to discover himself. In teaching the elementary facts of astronomy, we may discover a future Herschel, or a brief course in the elements of Geology or Mineralogy may enable a boy to discover that he has an abiding interest in such things; he may become a Dana. A young man of my acquaintance became interested in astronomy through reading one popular article on the subject. The speaker had a ten weeks' course on insects and one of the same duration on birds, and while he did not acquire an extensive knowledge of either subject, he developed an interest in both which has been retained, undiminished. To the criticism that elementary science gives only a smattering of several things we may reply that it is better to have a taste of all the branches of science than a distaste for all. In an elementary science course, one object has been attained when the students are prepared to choose more intelligently their elective subjects of the later years. Another writer states that elementary science should be a course that will introduce the students to the observing of natural phenomena and the recognizing of natural laws in a manner likely to maintain his interest and to stimulate his growth. It should furnish him with information which he is likely to find useful.

In a course outlined in one educational journal, the pupil studies fractional algebraic equations, involution, evolution, surds, exponents, triangles, circles, quadrilaterals, plotting curves, etc. The idea of this course is that elementary science is intended to bolster up the mathematical weaklings. If elementary science is put on this basis, it must inevitably fail. I, for one, do not believe

that elementary science is intended to act as a review of elementary algebra.

Another writer says: "To a deplorably large part of the community the striking of a match, the freezing of water, the falling of snow, the sending of a telegram, the operation of an engine, involve mysteries as profound as the cause of gravitation."

Lewis Elhuff says that general science has no more relation to future courses in physics and chemistry than it has to future courses in botany, zoology or anything else. Teach the student facts about his own health, the health of the family from which he comes, and the health of the community. A young lady who graduated from high school and college, had studied Latin eight years, Greek seven years, was one of the best mathematicians that ever entered the college, could not tell an oak tree from a pine. At picnics she did not hesitate to eat food over which flies had freely crawled. She was not educated. No one is educated if nature is a closed book to him. Among other things, elementary science should teach common things about the house, such as reading gas meters and putting on ball washers. It should teach the student to read with a greater understanding, much literature which abounds in scientific allusion. He should be able to read more intelligently popular scientific magazines.

If we examine a text-book of trigonometry, we shall find the laws of the sine, cosine and tangent; the formulae for one-half and double the angle, etc., but if we examine an elementary science text, what do we find? What is the author's conception of elementary science? Miss Pease in her book of 1915, devotes 45 pages to the elements of astronomy, 92 pages to the elements of physics; 28 pages to elementary chemistry; 88 pages to physical geography and 52 pages to biology. Barber in his First Course of General Science devotes 175 pages to heat and light; 135 pages to meteorology; 32 pages to ventilation; 175 pages to biology, and no attention is paid to chemistry or astronomy. Miss Clark, in her book of 1912, devotes approximately one-half of her book to physics and the other half to chemistry. For her, elementary science means easy chemistry and physics. Hessler gives one-half of his book to physics and chemistry. In a course outlined in School Science and Mathematics of November, 1912, elementary science is composed of physics and chemistry.

In the selection of the topics to be studied, why not co-operation

between the teacher and students? Is there any better way to maintain interest at the highest pitch than for the students to assist in selecting the subject matter? John F. Woodhull of Columbia University, says that whatever is worth while in astronomy, botany, chemistry, geology, meteorology, physics, physiology, zoology, etc., may be acquired.

An objection which is often urged against elementary science is that it is duplicated by the biology of the second year, or the physics or chemistry of the third or fourth years. If there is undue duplication the objection is a serious one because Dr. Eliot has said that boys and girls lose one and one half years in passing through our schools. This loss is due to the study of useless subject matter. If there is to be a further loss of time or efficiency by duplication, the public will rightly point the finger of condemnation at elementary science. A certain amount of duplication might be justified on the ground that it is a review. Many high schools duplicate their mathematics by a review of algebra and geometry in the second semester of the fourth year. However, I believe that the less duplication we have the better our course will be received by the public. Duplication can be easily avoided if the same teacher has all the science as is usually the case in small schools. Or it may be avoided by proper co-operation among the various science teachers or by the superintendent outlining all science courses. Bayonne avoids duplication by giving two years of elementary science based on the biological sciences and devoting the last two years to the specialized physical sciences. In some schools there is little chance of duplication in the case of most commercial students, because, while most of them elect elementary science as freshmen, very few elect the specialized sciences of the third and fourth years.

Another problem confronting some schools is lack of equipment. However, the ingenuity of the teacher should overcome very largely this difficulty because the equipment required for elementary science is not complicated.

Another problem is the dearth of properly trained teachers. Time will, no doubt, solve this problem.

Many teachers, if left free and unrestricted, will teach those divisions of their subject which they like best or in which they are especially well prepared,—hence, another problem is proper supervision so that the over-enthusiastic chemistry or physics devotee

shall not teach formal chemistry or physics when he should be teaching elementary science and making use of chemical and physical subject matter. In other words, it will sometimes be necessary to guard against an over-emphasis of one phase of elementary science at the expense of the others. This can be done either by supervision, an inspection of the teacher's plans, or by a definite course outlined by the superintendent. If this is not done, general science will lose one of its chief claims; i. e., that it is general: it will become special. The writer knows one teacher, an ardent advocate of evolution, who, while teaching general science, carried evolution so far that the clergy of the community said that she was teaching heresy. Surely this was a case for supervision.

In the small high school, the teacher of elementary science is usually the teacher of the other sciences and hence, besides his regular class work he has laboratory work in physics, chemistry or biology, and no time for any laboratory work in elementary science. But any science work to fulfill its highest mission must of necessity contain some laboratory work: the pupil must acquire a working knowledge of laboratory methods. A science course which neglects this, is not science, it is simply a revival of conditions of fifty years ago when science meant the mere study of a text-book. And yet, the speaker knows of elementary science courses which make no provision whatever for laboratory work.

As the writer sees it, general science is an attempt to break down the watertight compartments which have heretofore existed in our science teaching. These watertight compartments do not exist in nature, why should they exist in the school room? The mathematics teachers are coming to the idea of first year mathematics, second year mathematics, etc., instead of algebra, geometry and trigonometry being taught separately.

We may summarize as follows:

There must be a more general agreement as to subject matter.

There must be a more general agreement as to the object which is to be attained.

Avoid undue emphasis on any one topic.

Avoid or minimize duplication.

Make some provision for laboratory work.

Time will solve some of these problems; conferences and the columns of the General Science Quarterly will solve the others.

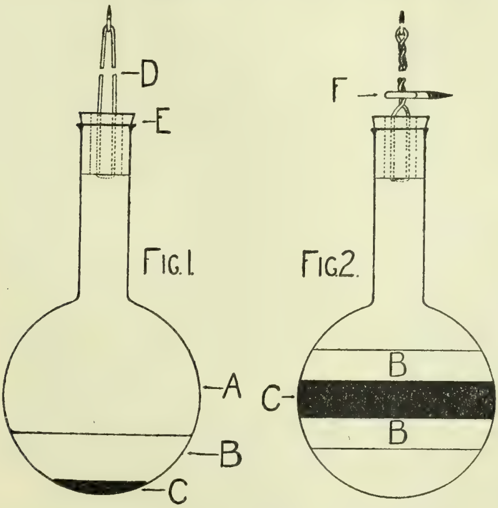
Home-Made Apparatus *

Herbert F. Davison, Head of Science Department,
Pawtucket, R. I., High School.

The pieces of apparatus illustrated in this article were shown by the writer at the Rhode Island Normal School, Providence, on January 13th, before a gathering of teachers interested in the subject of general science. So far as is known, they have never been illustrated in any book in the form here given.

The writer thoroughly believes that there is only one proper method of teaching general science to young pupils and that method is the one in which the teacher performs all the experiments before the class and then discusses the practical applications of the principle shown by the apparatus. This necessitates having considerable apparatus, and a teacher of some skill and dexterity in the handling of it. The latter is not always easy to get, but the former can be frequently made by the teacher, utilizing odds and ends found around the laboratory. Much can be done in elementary work with very cheap apparatus, because qualitative results in general are all that are aimed at.

These four pieces, selected from many that we use in Pawtucket High School, will be found to show clearly the principles they were designed to illustrate, and with little expense.

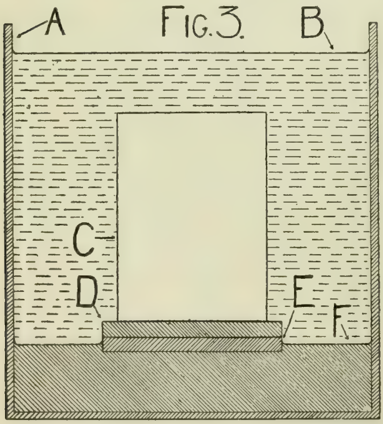


Figures 1 and 2 illustrate a very simple method of demonstrating the effect of centrifugal force on liquids of different densities (principle of cream separator). D is a cord about two meters long, doubled, and put through the holes of a two-holed rubber stopper, E. This stopper is jammed hard into the flask

* Drawings by Arthur Kirk, P. H. S., '17.

A, so that there will be no possibility of coming out. The liquids are mercury, and water colored with some dye, B. The screw-hook is screwed into a door frame or other convenient place high enough and the cord twisted by rotating the bulb between the palms of the hands. When it is so tightly twisted that kinks begin to appear, it is ready for use. On unwinding, the cord will give sufficient rotation to make the liquids take the positions shown in Figure 2. It is necessary to steady the cord a little just above the flask as the rotation gets rapid, because of the tendency to "wabble". This can be done with the first and second finger and thumb of one hand or by holding a small screw-eye as shown at F.

Figure 3 represents a device for showing that a body cannot float without water beneath it. The battery jar, A, has paraffin, F, poured in to make a bed for the plate glass, E. C is a cylinder of wood to which another plate of glass, D, is cemented with shellac. C and D together are of such weight as to float easily. But when they are pushed down upon the plate glass, E, they remain down, since there is no longer any upward pressure. When water leaks in between the plates, as it will do in a few minutes, the block floats again. This experiment is frequently done with mercury, but the lack of transparency of the mercury makes it impossible to show it to a large class this way.



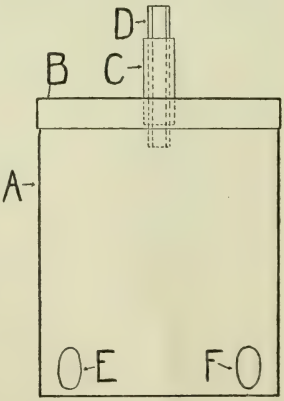


FIG.4.

Figure 4 represents a very simple device for demonstrating that although a mixture of combustible and supporter of combustion may burn, it will not *explode until the* PROPORTION of the ingredients is correct. A is a one-pound coffee can with a TIGHT-

FITTING cover. (Bend the cover to make a tight fit if necessary). Holes E, F, G, about one cm. in diameter are cut with a jack-knife blade. Into the top, B, is inserted a glass tube, D, 8 cm. long and 1 cm. internal diameter. To make the joint gas tight a piece of rubber tubing, C, is slipped over the glass tubing. The device is filled with illuminating gas by inserting a rubber tube into one of the holes in the bottom. When filled it is removed from the gas tubing and the gas issuing at the top of tube D, is lighted. It will burn with a yellow flame at first, denoting that only a small proportion of air is present, but will gradually burn bluer, due to the accumulation of air inside. Finally when the proportion is just right, the flame will be seen to descend in the glass tube and the whole canful of mixture will explode, blowing the cover several feet into the air.

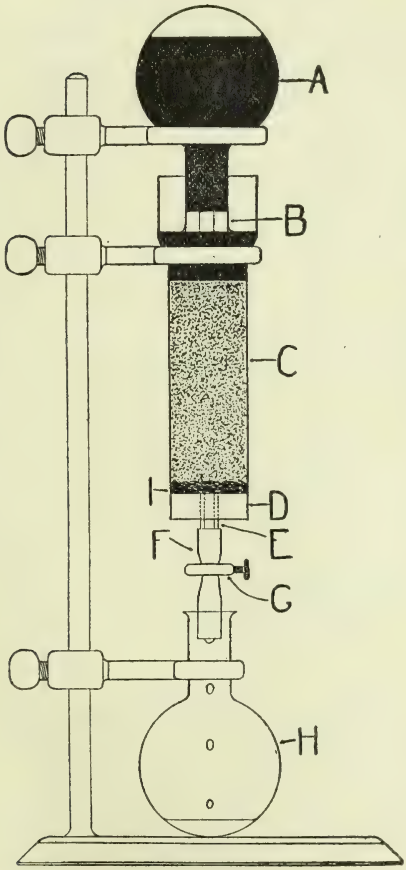


FIG. 5

The device shown in Figure 5 is an automatic decolorizing apparatus. It can be filled at the beginning of a lecture and by means of the stopcock, G, can be regulated to run slowly or rapidly. The student lamp chimney, C, is filled with granulated bone black on top of a layer, I, of excelsior. The flask A, is filled with a dilute solution of fuchsine or any other organic dye (red ink works well). The stopper, B, is necessary only as an aid in inverting, the large neck of the flask being too large to stop with the thumb. E is glass tubing inserted in D, a rubber stopper. F is rubber tubing and H a vessel of any clear glass. If the device is run properly, perfectly clear liquid only, comes into H.

General Science Bulletin *

(*Continued from page* 101.)

By Massachusetts Committee.

In the general unit, heat in the home, the following projects, demonstrations, laboratory exercises and topics may be included:—

A. Projects.

1. Construction.

   Fireless cooker. Fire extinguishers. Thermostat. Model heating systems. Model hot-water tank. Alcohol stove.

2. Interpretation.

   Gas stoves. Coal stoves. Steam heater. Alcohol stoves. Refrigerator. Matches. Oil stoves. Furnace. Hot-water heater. Hot-water tank. Ice-cream freezer. Gas meter.

B. Laboratory exercises and experiments.

The Bunsen burner.
What is the best fuel for a chafing dish?
Comparative cost of cooking by alcohol, oil and gas.
Is a high or a low gas flame more economical?
Study of a flame.
What is the best packing material for a fireless cooker?
Efficiency of a fireless cooker.
The fireless cooker as a refrigerator.
Testing thermometers.
Effect of surface on the rate of cooling.
Non-conductors—conductors.

C. Demonstrations.

The manufacture of illuminating gas.
Construction and operation of hand fire extinguishers.
How to read a meter.

D. Topics.

History of heating systems. Bunsen and the Bunsen burner. Natural gas. Gas manufacture and distribution. Central heating plants. Manufacture of alcohol. By-products of the gas works. Coal mining. The story of coal. How matches are made. Safety matches. Pyrometers. The making of a thermometer. Petroleum and its products.

* Preliminary draft.

2. Our Water Supply.
   A. Projects.
      1. Construction.
         Filter for household use. Model of city filter.
      2. Interpretation.
         Study of reservoirs (location, physical features, elevations as shown by topographic maps, etc). Wells. Cisterns. Purification of water. Water storage and distribution. Hard and soft water. Water in vegetables. Springs.
   B. Demonstrations.
      Distillation. Model of water system. The cause of water pressure. Intermittent springs. The siphon. Pumps. Hydraulic press. Hydraulic ram.
   C. Laboratory exercises.
      Water tests. Charcoal as a filter. Efficiency of faucet filters. Tests for hard and soft water. Methods of softening water. Quantity of water in foods. Water pressure.
   D. Topics.
      Water-supply systems. Forests and water supply. Saving the water. National irrigation projects. Rivers of ice. The work of rivers. Work done by ice.
   E. General questions.
      Why do crackers become moist but bread dry in the same air?

      Why does a drowning person rise three times?

      How can fish live in a frozen pond?

      How cold is the water at the bottom of a frozen pond?

      Does the ocean ever freeze?
3. Cleansing and Dyeing.
   Making soap (laboratory or home). Making ink eradicators. Javelle water. Making cleansing fluids. Commercial dyeing. Bleaching of cloth. Other bleaching processes. A laundry. Physical and chemical changes. Solutions. Making of alcohol. Preparation of ammonia. Removal of stains. Alkalinity of soaps. Tests of washing powders, cleansing fluids, stain removers, etc. Dyeing of cloth, raffia, etc. (laboratory). Where do we get our dyes?

What are some of the different kinds of ink? How is benzine prepared? How is ether made?

4. Our Food Supply.

Making flavoring extracts. Preparation of starch. Coffee tests. Butter tests. Pasturized milk. Starch and sugar in foods. Color in foods. Sources of food supply. Making butter. Coffee growing. Making ice cream. Tests for coal-tar dyes. Other dye tests. Babcock milk test. Preservatives in milk. Food adulteration. Study of food preservatives. List of pure foods. Food values. A well balanced diet.

The food unit may be organized as follows in projects, demonstrations, experiments and topics:—

A. Projects.

1. Construction.

Preparation of different articles of food, as the baking of potatoes; boiling potatoes; roasting and boiling meats; making bread; canning and preserving foods; making up a menu for a family with estimates and costs, total and per capita.

2. Interpretation.

A study of sample menus given in newspapers or in cook books.

Report of the meals of a family represented in the class.

A study of the work of the local board of health as regards protection against poor food.

How the milk supply of the city is safeguarded.

Prices of different kinds of food. A study of patent cereals.

Estimates of costs of prepared foods against the same material in bulk.

B. Demonstration.

Tests of adulteration in foods. Various methods of preserving foods. Analysis of food materials, as proteins, carbohydrates or starches and sugar.

C. Laboratory exercises and tests of food adulterants by pupils.

Extraction of fats and oils by solution. Tests for various food materials.

D. Topics.

Adulteration of foods, including history. The government

Pure Food Bureau. Sources of food supply. The flour-milling industry. Cattle ranches of the west. The United States Fish Commission and its work. Fish hatcheries. Comparison of prices of food in this and other times.

Other food tests, and the study of the characteristics and value of various foods, may be made *ad lib.* In this connection it would not be out of place to consider—

Soil formation.

Action of glaciers, earthquakes, volcanoes, wind, water, chemical action, vegetation, temperature changes, avalanches, animals, human agencies, etc.

5. Our Animal Associates.

(a) Profitable.	(b) Harmful.
Bacteria.	Potato bugs.
Toads.	Elm beetle.
Birds, etc.	Gypsy moth.
Earth Worms.	Brown-tail moth.
Domestic Animals.	Flies and mosquitoes.
	The house cat, etc.

6. Keeping Well.

The sanitary house.	The sanitary town.
Sewers.	Preventable diseases.
Personal hygiene.	Preparation of food.
The teeth.	Tooth preparations.
Headache preparations	Habit-forming drugs.
Patent medicines.	Toilet preparations.

7. The Weather.

Study of almanacs.	Air pressure.	Dew.
Thunder storms.	Storm signals.	Frost.
Weather instruments.	Light ships.	Rain.
Weather maps.	Lighthouses.	Winds.

This general unit is available because of the universal interest in the subject. It affords an opportunity for a wide range of experimentation, observation and reading. The problems presented for consideration come within the range of the experience of boys and girls in general science classes. There is a wealth of material available for reading purposes. The study of the weather involves the examination, description, use and construction of certain instruments and devices which in turn suggest far-reaching scientific principles. The pupil is brought into direct contact with

phenomena of changes in form and substance, such as water to vapor; water to ice; rusting of iron; erosion of soil; deposit of silt. The desire for knowledge in this field is easily roused and gratified because of the background of experience possessed by the pupils. Further study and reading are easily stimulated. Among the projects included under the general unit of "weather" are the following:—

A. Projects.

1. Construction.

To make records of weather changes with or without instruments. To construct a rain gauge and make observations with it. To record data from government reports upon a map of the United States. To make a barometer.

2. Interpretation.

To compare almanac and official weather predictions. To compare actual weather conditions with almanac predictions. To find what predictions in an almanac are reliable and based on scientific data.

B. Demonstration.

The use of the hygrometer; wet and dry bulb reading; maximum and minimum thermometers.

How boiling point, freezing point and zero are determined. The aneroid barometer and its use.

C. Experiments.

Establishment of dew point. Proof that air contains moisture. Expansion of water on freezing.

D. Topics.

The government Weather Bureau. Superstitions relating to weather, including folklore, and an attempt to discover to what extent these sayings are based on actual facts. Description of government weather map. The local weather bureau and its work. Notable storms.

8. What Time is it?

Local time.	Noon by local time.	Time on the ocean.
Standard time.	Time by wireless.	School clock system.
Railroad time.	Time signals.	Clocks and chronometers.

A. Projects.

1. Construction.

Assemble parts of a clock. To make a sun dial. To

make an hourglass. To make a water clock. To study the mechanism of a watch.

2. Interpretation.

Various kinds of clocks. Chronometers and their use. How natural forces are used in the clock or watch. How does a pendulum regulate the time? Local devices for regulating watches and clocks.

B. Demonstrations.

The operation of a pendulum. How noon is determined by the sun.

C. Experiments.

The general law of the pendulum,—avoid emphasis on quantitative standards. Testing the accuracy of a watch or clock.

D. Topics.

A modern watch factory. The history of watches. Early devices for measuring time. Different calendars. Standard time in the United States. Daylight, a saving device. How small portions of time are measured. Stop watches. How the heavenly bodies may be used in determining time. Astronomical observations and time. Work of the Greenwich Observatory.

9. Ventilation.

How houses are ventilated. Measurement of the ventilation of a room at home. How our school is ventilated. Tests of the efficiency of school ventilation. Carbon dioxide in the air. Study of the air. Preparation of oxygen. Properties and uses of oxygen. The ventilation of theatres. Ventilation of public building. Ventilation of factories. Ventilation of stores. Ancient and modern methods compared.

10. Household Electrical Devices.

The electric toaster. Electric chafing dish. Electric flatiron. Electric bell. Electric stove. Electric coffee percolator. Electric water heaters. Burglar alarms. Efficiency and cost of operation of electrical devices as compared with similar devices operated by other means. Measurement of electricity by meters.

11. Commercial Uses of Electricity.

The electric telegraph. Its invention. Making a tele-

graph instrument. The Morse code. The use of the Morse code in heliographing and in other forms of signalling. The first Atlantic cables. A map of the ocean, showing the cable systems. Curiosities of long-distance telegraphing. How may money be sent by telegraph? The wireless telegraph.

The telephone. The description of a telephone. Making a telephone. Making a small telephone circuit. Description of the telephone of a city or town. Long-distance telphone.

Wireless telephone.

Electricity in an auto: the magneto; the spark coil,—how each operates.

Electromagnete in surgery and in factories and stores.

Electroplating. Electrotyping.

The sign flasher. Fire alarm systems. X-ray.

The story of electricity.

12. Transportation.

A wheelbarrow.	Steel rails.	Street cars.
Steam cars.	Removal of snow.	Automobiles.
Bicycles.	Good roads.	Motorcycles.
Boats.	Welding.	Aeroplane.

13. Our Neighbors in Space.

Practical value of the work of the astronomer.

The north star and the compass.	The moon.
Sunrise and sunset graphs.	The solar system.
The sun.	Constellations.
The stars.	Latitude by Polaris.
Comets and meteors.	Astronomical day.
North by Polaris.	Making a sundial.
Famous astronomers.	Sunshine recorders.

14. The House we live in.

The forests.	Imported woods.
Timber supply.	Characteristics of woods.
Bark. Charcoal.	Clay and bricks.
Wood alcohol.	Stone used for building.
Acetic acid.	Making concrete.
Forests and drainage.	Uses of concrete.
Forest fires.	Reinforced concrete.
Waste lands.	Glass. Slate. Mortar.

15. Street Lighting.

Gas arcs.
Kerosene lights.
Location of poles.
Measuring the light.
Electric light.
Cost of lighting streets.
Electric arcs.
Acetylene street lights.
Height of lights.
Incandescent lights.

History of its invention.
Description of an arc lamp.
Description of an incandescent lamp.
Different makes of incandescent lamps.
Making an electric light system.
The electric bell and other signals.
Use of electricity in railway signalling.
Great inventors in electricity: Edison, Faraday, Morse, Alexander Graham Bell.

16. Home Lighting.

Kinds of lights. Indirect lights. Effect on air. Location of lights. Lamp shades. Comparative costs. Quality of the light. Style of fixtures. Quantity of light.

17. Commercial Lighting.

Lighting of store windows. Decorative lighting of buildings. Special displays. Lighting of public buildings. Theatre lights and light effects. Dimming of lights. Illuminated signs.

18. Taking Pictures.

Making a camera. How to choose a camera. Light and silver salts. Gelatin printing. Ray filters. Taking the picture. Developing. Blue prints. Exposure meters. Lantern slides. Flash lights. Enlarging. The history of picture taking. Daguerre and his successors. Home portraits.

19. Insect Pests and How to Fight Them.

A. Projects.

1. Construction.

Destroying insect pests.
Observing the habits of some injurious insect.

2. Interpretation.

The life history of the gypsy moth; elm-tree beetle; potato beetle; grasshopper; locust.

B. Demonstrations.

Methods of fighting insect pests with local illustrations.

C. Experiments.

Operation of various substances used in fighting insects, as Paris green; tests for same. Caution against exposure to such poisons. A collection of warnings by government officials. Study of the life history of some insect. Collection of specimens.

D. Topics.

Literary and historical allusions to insect pests. The work of the government. The work of the State. Money losses.

20. General Questions.

In connection with the various units, interest and curiosity may be stimulated by the introduction of striking questions, and questions commonly asked but seldom answered. The following are examples:—

Of what value is odor to a flower?
Why have some flowers no odor?
Is the length of the day constant?
Why does not dew "fall" on a cloudy night?
Why is the seashore cool in summer?
Is night air dangerous to health?
Why does a bursting bag make a noise?
Where does the flame go when the candle is blown out?
Why does blowing put out a candle?
Why does a baseball curve?
What makes a balloon rise?
How high will a balloon rise?
Why does a breeze make us cool?
What color of wall paper is barred from an insane asylum? Why?
Why do cats always fall on their feet? Do they?
Why is it "darkest just before dawn?"
Why are colored globes used in windows of drug stores?
Why are barbers' poles striped?
Why is not a bird on a trolley wire electrocuted?
Where does the day begin?

(To be continued)

How Shall We Organize Our General Science?

By E. M. Libby, Presque Isle High School, Maine.

The great objection which is frequently raised against general science is that it is as yet an unorganized subject. The critics say, "You are teaching a lot of unrelated facts without regard to logical order." Another objection often raised is that "General science as usually taught at the present time is a good example of soft pedagogy, and soft pedagogy is dangerous."

The writer wishes in this brief article to give a few facts from his own experience relating to the two problems just mentioned. He has been experimenting upon this subject for several years and is now teaching about seventy-five high school freshmen. The class has copies of the Caldwell and Eikenberry text, but they are used only for reference work.

The form of organization which seems to me best is something very similar to the plan proposed and discussed in a recent number of the General Science Quarterly by Fred D. Barber. This scheme proposed that the science work for the first-year course be built up around the phenomena of the home, the street, the school, and, I would add, in this section, the farm.

I have learned by experience that the phenomena which will prove of greatest interest to the pupils are very likely not to be those which appeal to me. This year I asked my class to make lists of questions about the things which they saw about them every day and which they did not understand. The results which I obtained were very interesting and suggestive. I have a whole bundle of questions, covering every conceivable branch of natural science and yet dealing only with things and events familiar to the everyday lives of the young people. I took these lists of questions and am grouping together those which have a natural relation. For example there were very many questions having to do with electricity. I am trying to answer all of these by a brief—very brief—course in electricity, trying especially to touch upon explanations which answer the questions raised. In reply to the assertion that we are teaching simply a collection of facts, I would say that in any science the results will depend very largely upon the teaching. I think that the facts taught in such a course as I am describing *are* important, but I think that the attitude to-

ward scientific truth which may be developed is perhaps of still greater importance, and I believe that this may just as well be developed by the study of phenomena in which students have a present vital interest as in the consideration of truth which to them is more remote and abstract.

In reply to the assertion that our general science is an example of soft pedagogy and requires no work on the part of the student, I would say that we school teachers sometimes seem to think that no work counts except what we require to be done. I believe that the work of the world which counts most is work which is done because the worker is interested in it and wants to do it. I know that many of my science students are to-day reading scientific articles in text books and periodicals because they want to find out more about matters suggested in the class room, although this outside reading is merely suggested and in no way required. I suggest that for a high school freshman to master the subject of electro-motive force as explained in Milliken and Gale's Physics text book might be termed work, and I know that many of my class have done that with considerable success during the past two weeks.

Painting by Ford Madox Brown *By permission of the Town Hall Committee of the Manchester Corporation*

JOHN DALTON COLLECTING MARSH GAS

From "An Introduction to the History of Science" by Walter Libby. Published by Houghton, Mifflin Company. Used by courtesy of author.

General Science Quarterly

Vol. I. MAY, 1917 No. 4

The Springfield Plan

Howard C. Kelly, High School of Commerce, Springfield, Mass.

"I have heard of the Springfield plan. Please send me your course of study." Again and again this request has come to us from the teacher seeking help, from the teacher in search of statistics, and from the critic. Each of these is disappointed and apparently shocked when we try to point out that we lay no claim to having solved all of the problems of general science, and that our "course of study" is not a panacea for all the ills to which that subject is heir.

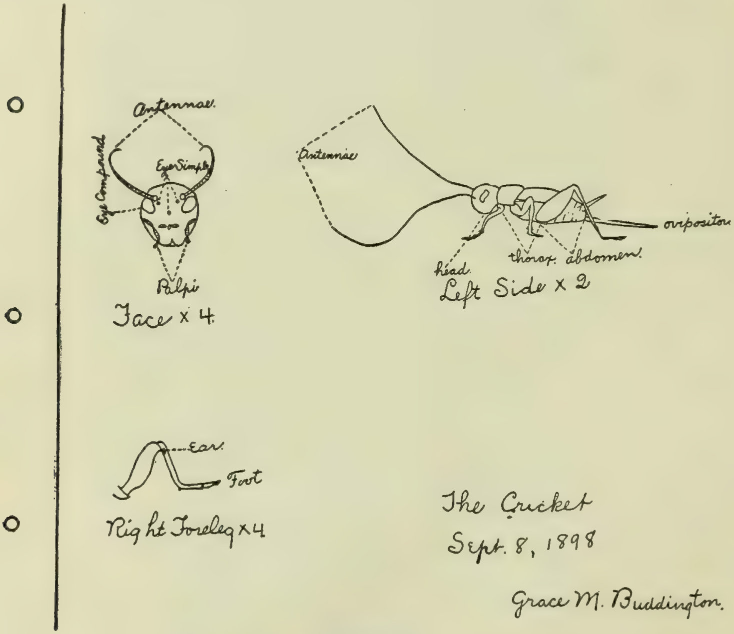
The "Springfield Plan" is not a course of study. It is a method of instruction which has served *our* needs well. This method is not peculiar to general science. It may be applied with equal facility to any and all science courses.

The "Springfield Plan" is not exactly a plan, either. It is, rather, the result of the growth of an idea; the result of study, trial and experiment. In attaining this result, the teacher has been absolutely unhampered. There has been no final examination to be met, no college requirement to consider. The only aim has been to minister to the needs of the pupil in the best possible manner.

This article is a brief story of that growth. It tells of a changing point of view, and a gradual approach to a more nearly satisfactory solution of the problem of elementary science.

When the new Central High School building was opened in September, 1898, great emphasis was being laid on the study and teaching of biology, particularly as a first year subject. This is well shown by the allotment of rooms in the science department. Of the eight rooms given over to science, four were biological laboratories, one a chemical laboratory, one a geological laboratory, and

two were physical laboratories. Exactly one-half of the science space was to be devoted to biological instruction. The course designed for the Freshmen, and required of them, was one in biology, so-called, and consisted of a half year of zoology and a half year of botany. The work was done mainly in the laboratory, and the nature and content of the course is well shown by the following outline and specimen page from the note book of a pupil who entered the school that year.



BIOLOGY.

Central High School, Springfield, Mass.

1898—1899

THE CRICKET. Drawing—1 page. (See cut.) Description. Sense organs. Metamorphosis: direct; indirect.

THE SPIDER. Drawing—1 page.

THE EARTHWORM. Drawing—1 page. Description.

PROTOZOA. Drawing—1 page. Protoplasm. Root animalcules. Gregarines. Infusoria. Amoeba: 1. Habitat. 2. Structure. 3. Feeding. 4. Excretion. 5. Respiration. 6. Locomotion. 7. Irritability. 8. Reproduction. 9. Resting stage.

PORIFERA. Drawing—1 page. Description. Classification.

THE HYDROID. Drawing—1 page. Description.

THE SEA ANEMONE. Drawing—1 page. Description.

HYDRA. Description.
THE STAR FISH. Drawing—3 pages. Description.
THE TULIP. Drawing—2 pages.
HORSE CHESTNUT. Drawing—2 pages.
CHERRY TWIG. Drawing—1 page.
SQUASH. Drawing of seed and plant—1 page.
CORN. Drawing of seed and plant—1 page.
THE PEA. Drawing of seed and plant—1 page.
THE VIOLET. Drawing—1 page.
STARCH. Drawing of starch grains—1 page.

EPERIMENTS:

1. Does light assist germination? Does light retard germination?
2. Will seeds germinate without air?
3. Are the cotyledons of a seed of any use to the seedling?
4. Does the amount of material in a seed have anything to do with its germination?
5. Of how much use to the corn seedling is the endosperm?
6. Do seeds contain starch?
7. How can the presence of grape sugar be detected?
8. What change does the starch in seeds undergo during germination?
9. Do seeds contain oil?
10. Do seeds contain proteids?
11. How is the growth of the pea carried on after the destruction of the plumule?
12. Do two liquids in contact with one another mingle?
13. Can two liquids separated from one another by a moist membrane mingle?
14. If the two liquids in Experiment 13 are of unequal density, is the greater flow from the denser to the less dense or vice versa?

THE RADISH. Drawing—1 page.
ROOT OF DAHLIA. Drawing—1 page.
UNDERGROUND STEMS. Drawing—1 page.

This course was intended to introduce the pupil to the world of science and to arouse his interest in science work, but in meeting the latter part of this aim it was not an unqualified success. It was worked out according to the best pedagogical practice, but instead of interest, a marked distaste, almost amounting to disgust, appeared. "How we hated that old bugology! I can smell the pickle yet," said one of the pupils to me recently. Work of this sort, particularly the zoology, is by its very nature calculated to arouse either intense enthusiasm or profound dislike—the enthusiasm being limited, usually, to a very few. As a matter of fact, no one science will ever arouse and hold the interest of a class composed of a large number of individual boys and girls whose tastes

run to all sorts of extremes. In this case biology failed because, as taught, it was a subject too deep for the age of the pupil, requiring skill in dissection, clearness in reasoning, and the ability to differentiate.

The course continued, however, in substantially the same form for six years, becoming more and more unsatisfactory all the while. Occasionally a teacher of more than ordinary ability could make the work endurable, but on the whole, it failed to prove its right to an existence. It was found, also, that the unsatisfactory introduction to the science work was reacting unfavorably on the whole science department. The size of classes in the elective sciences was decreasing, because to the pupil "science" was synonymous with the course in biology. It was evident that some radical change must be made if the science was to hold the place it deserved in the work of the school. To none was the need for a change more evident than to Dr. Thomas M. Balliet, then Superintendent of Schools, and Mr. William Orr, then Principal of Central High School, and Springfield owes whatever of credit she has received for originating a plan of first year science work to the courage and foresight of these two men—a fact which they are far too modest to admit.

It was determined to break sharply with the old course and to start afresh along new lines and with somewhat different aims. The purpose of the new course was two-fold:

1. To give the pupil a broad and helpful view of the whole field of science, especially as it touched his daily life.

2. To lay special emphasis upon the fact that the science of the school and the science of the "outside world" are identical.

In scope, the course has gone far beyond even the dreams of the far-seeing men who planned its beginning, but it has adhered steadfastly to their ideals, and with uniform success.

In September, 1904, Mr. Waterman S. C. Russell was secured to be the first teacher of the course, and to him is due the credit of instituting a practical plan of work. On account of conditions within the science department, the course for the first year consisted mainly of mild physics, with numerous practical illustrations, together with some chemical notions, but the relief from the strain of the biology course was evident immediately, and there was every inducement to continue. The next year something of astronomy crept in, and the course became more definitely and distinctly re-

lated to the home. Little by little the other sciences found their place, until the course became in fact, as well as name, a course in *general* science.

Almost from its inception the epithet "hash" was thrown at the work by those who failed to appreciate its purpose, or who were definitely committed to some one subject, such as biology or physiography, as an introduction to science. To some extent this criticism was justified. The various problems—the term "project" was not in use at that time—were not closely related, and there was a lack of cumulative effect, which made it difficult to group the knowledge and experience gained under general heads.

This need of closer and more systematic organization was felt quite as acutely by the friends of the course as by its critics, and various plans for overcoming the difficulty were tried. The final solution was the organization of the material into a number of large general units, each having a definite relation to the life of the city, and, therefore, a definite interest to the pupil. Problems thus presented seemed to him worthy of solution. He could, and did, bring to bear his previous experience, and he could appreciate, to a much greater degree, the general underlying principles.

It was found, also, that this method brought together the whole family of sciences in harmonious relations. For example, one unit studied—the classic one—is "Springfield's Water Supply." When this is studied from its source in the springs and brooks to its use in the homes of the pupils, it is necessary that reference be made to almost every branch of science, though the specific names of these branches may never be mentioned. Physics and chemistry, biology, physiography, bacteriology, forestry and sanitation—a knowledge of each is essential to the construction and proper operation of a modern water system. In a similar way other common activities may be grouped into general units, and taught more effectively and forcefully than as isolated topics, each comparatively meager in content. As a practical working plan, this system needs no defense. Its success is its own justification.

With the formal inauguration of the junior high school in February, 1917, a new situation was produced. Previously each of the three high schools had determined its own course. Now it became necessary to formulate one uniform course which should be acceptable to each of the senior high schools, and which should not be a hindrance to any pupil in future science work. Somewhat to the surprise of all, the heads of the science departments in the

three high schools were found to be in complete accord, and with principals of grammar schools and the supervisor of nature study in agreement, the following course was suggested and adopted:

GENERAL SCIENCE.

JUNIOR 3.

Outline of the Course

PURPOSE.—The chief purpose of this course is to offer an opportunity whereby the pupil may broaden and deepen his interest in natural phenomena. His study of the subject should promote a wide outlook, and should minister to his intellectual life by the gratification of mental desires in an increasing appreciation of the delight and satisfaction to be found in the study of nature.

The primary aim of general science is to give large opportunities for the exercise, along the line of the pupil's interests, of his inherent desire to know more of his physical environment, rather than to require the mastery of a certain body of organized knowledge or a command of formulae, or to develop expert scientists, or to train explicitly in scientific method.

Instruction in general science should lead to a more extended reading of articles on science, in magazines and newspapers, and of scientific books of both popular and technical character. There should be a readier understanding of scientific allusions, increasingly found in general literature.

The pupil should learn, also, how to use certain instruments and appliances, as balances, rulers, and graph paper. Practice should be given in the systematic arrangement of data in tabular form and graphic presentation. The pupils should gain in skill and power to use reference books, such as dictionary, encyclopedia and readable texts. Information on scientific matters should thus be made easily accessible.

ORGANIZATION OF THE COURSE.— In organizing the course, the following factors should be kept constantly in mind.

1. The course is to be planned with particular reference to Springfield, its location, its interests and its needs.
2. It is to be a course in *general* as opposed to *particular* or specific science.
3. It will be a half-year course, that is, five (5) periods of work a week for twenty (20) weeks.
4. It is to include a considerable amount of laboratory work done by the pupil, either in school or at home.
5. It should consider carefully and, in every way possible, build upon the work previously done in the grades. Incidentally, it should include a continual review of former science work.

ORGANIZATION OF MATERIAL.— General science material should be organized as a number of general units. Each unit should consist of a large central theme involving problems of various kinds so re-

lated to the experience and interests of the pupil as to make him feel that their solution is worth while. These problems should of themselves make it clear that the science of the school and the science of the "outside world" are identical.

When these units are wisely selected and well organized, the pupil should find something in each to arouse genuine enthusiasm and to challenge to vigorous effort. While at times the several problems in a unit may seem to be unrelated, when the results are summarized the relation of each to the main unit should be clearly seen.

While each project or problem in a given unit should be complete in itself, cumulative effect is produced by grouping together a number of projects belonging in the same field. Without such relationship a succession of isolated and comparatively limited projects and undertakings will result, and there will be failure to group the knowledge and experience gained under general heads.

OUTLINE.— The following general units are selected for this course. As it will be found impossible to complete, even approximately, all of them in the space of the half-year allotted, certain portions have been starred (*) as required. The remaining portions may be considered, as time permits, at the discretion of the teacher and according to the bent of the class.

1. Foods.
2. The Houses We Live In.
3. Keeping Well.
4. Cleansing and Dyeing.
5. Household Electrical Appliances.
6. The Weather.
7. Our Neighbors In Space.
8. What Time Is It?
9. Springfield's Water Supply.

These units may include, along with reading, study and original investigation by the pupil, the following lectures, or talks *with the class*, and exercises, laboratory or home, which bear upon the same subjects.

FOODS

CLASS TALKS	EXERCISES
*Food and Its Adulteration.	*Coal Tar Dyes.
*Color in Foods.	Other Dye Tests.
Coffee and Its Relation to Health.	*Coffee Tests.
*Milk and Butter.	*Butter Tests.
*Eggs.	*Babcock Milk Test.
Food Preservatives.	Preservatives in Milk.
*Flavoring Extracts.	Pasturized Milk.
Science and the Food Supply.	Ice Cream.
Food and Health.	*Study of Eggs.
	*Making Flavoring Extracts.
	Preparation and Test of Starch.
	Starch and Sugar in Foods.

THE HOUSES WE LIVE IN

The Forest and Its Products.
Clay and Bricks.
Cement and Concrete.
Wood Through a Microscope.
*Ventilation of the House.
*Heat in the Home.
*Fires and Fire Extinguishers.
*Home Lighting.
Science and Decoration.
*Carbon Dioxide In Air.
*Testing the Ventilation of a Room.
*Cost of Some Fuels.
*The Hot Water Tank.
*Our Home Heater.
Our Refrigerator.
Ice Cream Freezers.
*The Fireless Cooker.
Testing Lights.

KEEPING WELL

The Sanitary Home.
Personal Hygiene.
*Tooth Preparations.
*Headache Preparations.
*Patent Medicines.
*Habit Forming Drugs.
*Preventable Diseases.
*Test of Tooth Preparations.
Making Tooth Powders & Pastes.
Test of Headache Preparations.
*Toilet Preparations.
*Moulds.
*Growing Bacteria.

Note:—Constant reference will be made to matters of health and hygiene in connection with other work of the course.

CLEANSING AND DYEING

*Physical and Chemical Changes.
*Soap and Its Uses.
Removal of Stains.
Bleaching.
*A Trip Through a Laundry.
Dyeing at Home.
Where Do We Get Our Dyes?
*Litmus Tests.
*Making Soap.
*Tests of Ink Eradicators.
Javelle Water.
*Removing Common Stains.
Tests of Washing Powders.
Tests of Cleansing Fluids.
*Dyeing Tests.
Inks.

HOUSEHOLD ELECTRICAL APPLIANCES

*The Story of Electricity.
*Heat and Light From Electricity.
Other Electrical Effects.
*How Electricity Is Produced and Measured.
*Electricity In The Home.
The Electric Bell.
Bell Wiring Problems.
*Tests of Household Electrical Devices.
*Lamp Tests.

THE WEATHER

*Our Atmosphere.
*Air In Motion.
*Clouds, Fog, Mist, Rain, Dew and Snow.
Work of the United States Weather Bureau.
Effects Produced by Weather.
Water Power in New England.
Testing Air for Oxygen and Nitrogen.
*Temperature Graphs.
Dew Point and Humidity.
*Weather Record.
Making a Weather Map.
*Almanac Weather Predictions.
*Rainfall and Forests.
Water Power Map of New England.

Note:—The study of the weather, particularly the keeping of records and notes on special conditions, should be continued throughout the semester.

OUR NEIGHBORS IN SPACE

*Astronomy of Everyday Life.
*The Moon, Our Nearest Neighbor.
*The Sun, Our Distant Neighbor.
*The Planet Mars, Our Sister World.
*Comets and Meteors.
*The Stars, Our Very Distant Neighbors.
*Finding a Meredian.
*Monthly Record of the Moon.
*Sunrise and Sunset Graphs.
*Heat From the Sun at Different Angles.
*Constellations.
Latitude by Altitude of Polaris, or by Gnomon.

WHAT TIME IS IT?

*Local and Standard Time.
*How Time Is Kept.
Ancient.
Modern.
*The Calendar.
*Map of Time Belts.
*Rotation of the Earth and Its Effects.
Longitude of Springfield.
Time Signals.

SPRINGFIELD'S WATER SUPPLY

*Growth of Our Water System.
*Reservoirs and Their Location.
*Purification of Water.
Conserving the Supply.
*Water Pressure.
*Water Tests.
*Charcoal as a Filter.
*Household Filters.
Hard and Soft Water.

TEXT BOOKS.—Text books should be used mainly for reference purposes, and not as an outline of a course. It is desirable, therefore to have at hand a number of different texts, and those already in use in the several high schools should be turned over to the Junior High School as soon as practicable.

Leaflets, each dealing with some particular project, and prepared especially for local use, make the best text book in the commonly accepted meaning of that term. They should be prepared largely by those in charge of the work and printed, if possible, by the Practical Arts classes in the various schools. The use of such leaflets relieves the pupil of the somewhat arduous task of writing up reports of lectures, and serves the purpose equally well.

LABORATORY MANUALS.— The laboratory manual, like the textbook, should be made to fit our own particular needs. The various exercises should be printed. The teacher can give directions, when these are needed, more easily and clearly, and as the time sometimes wasted in dictation is saved, more real work can be done in a given number of lessons. The pupil escapes the purely mechanical work of recording results, a task which too frequently causes him to miss the real point of the exercise which he has performed. This in no way lessens the training in orderly arrangement of material, and will often prevent the pupil from becoming discouraged. The production of an elaborate system of notes is not one of the purposes of the course. The note book should be considered a means rather than an end.

The foregoing represents the last stage, to date, of the "Springfield Plan." We do not accept it as final. It is not even our ideal. We are looking for improvement, but it seems to be, *for us,* the best solution of our present problem, and that, after all, is about the only qualification that we can absolutely demand of a course in general science.

History of the General Science Movement[1]

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The story of the General Science Movement traces itself through many years, but not until recently has it become significant in aiding the science teacher to meet the demand for an improvement in science instruction. The history of the teaching of general science is still to be made. It had a beginning that was curtailed fifty years ago, and the revival is just appearing. Since the break, as far as the writer is aware real general science, the kind that is discussed by Professor Woodhull in his "Science Teaching by Projects"[2], has not been prominent in any school. All we can trace is the history of the opposition to, and the breaking away from methods which are a check on the pupil's natural progress.

[1] Abstract of an address delivered at Teachers College Science Round Table.
[2] School Science and Mathematics, March, 1915.

The academies in the seventeenth and eighteenth centuries represented in more ways than one a revolt against tradition. In Isaac Watts' "Free Philosophy" we read:

> "I hate these shackles of the mind
> Forg'd by the haughty wise;
> Souls were not born to be confin'd
> And led like Samson blind and bound,
> But when his native strength he found
> He well aveng'd his eyes."

This was in the seventeenth century. Ferguson, of the next century, can be considered one of the earlier advocates of general science, though that term was then unknown. There is nothing to prevent our going back still further to earlier scientists, but to keep within rational limits let us begin here. In speaking of Ferguson's book Professor Mann says: "An inspection of the contents of this book shows us why the knowledge it contained was useful. Sixty-two pages are devoted to mechanics, and forty pages to pumps . . . An age of machinery and invention, an era of rapid industrial expansion, was developing, and the classics were unable to meet the demand for information on these subjects . . . A new type of information was needed and demanded by the public; and natural philosophy and the other sciences were invoked to meet the need and supply the demand."[3]

Pioneers of science, such as Faraday, Arnott, Davy and Ferguson, famous for their ability in the field of science, were at the same time genuine teachers of science. In their lectures they taught an almost ignorant public facts that today would be considered difficult. This they accomplished by popularizing their subject matter.

In 1869, George B. Emerson in his treatise on "Education in Massachusetts" shows what the reactionaries of that day stood for. Speaking of the children of a century or two earlier he says: "In winter they helped to clear the woods and cut down the forest trees, sledded the logs to the wood-pile and the timber to the mills, and assisted at first in hewing it, afterward, in sawing it into beams, posts, joists, planks, boards, clapboards, and shingles, or squaring it and building it directly into houses. . . . Has any system been

[3] C. R. Mann, Teaching of Physics, pp. 32-3.

devised to take the place of this and give the young man, in a higher degree, full possession of all his powers and faculties of body and mind, or to give him, in the same degree, the masculine qualities of hardy self-reliance with cautiousness, manly courage with coolness, resolution with patience, and power of endurance with habits of strenuous and cheerful labor? . . .

"Everybody is now ready to admit the important place which natural and physical science should have in a liberal education; but all are not aware that such science, to be real, must be founded on personal observation. These boys were laying such a foundation. A boy engaged in stoning a well, in raising stones for a wall, or in drawing water from the well by an old fashioned well-pole, was studying the properties of the lever. In splitting logs, he became acquainted with the wedge; in making roads, with the inclined plane. In helping to lay out a farm, with a surveyor's chain and compass, so as to fix, justly and accurately, the bounds between neighbor and neighbor, he got the first elementary ideas which lie at the very foundation of geometry . . . Even in his play he was still at his studies. In rowing, he was studying the lever; in sculling, the resolution of forces,—feeling as well as seeing . . . When for the well-pole he substituted the windlass, and with it drew water from the well, he was learning the nature, by observing the uses of the wheel and axle . . . Such was the necessary but real and noble preparation for college which was given to nearly all the boys in Massachusetts purposing to receive the highest education of the time. Has anything better been yet introduced to take the place of such a preparation? Does the vast time given to arithmetic, destined to be never used; or the innumerable lessons in geography, destined to be speedily forgotten; or the volumes of choice and exquisite selections from the best and finest poetry and prose, most of it wholly beyond the capacity of those who are to read them,—give a better preparation?"[4]

And later he says: "What a pleasant way of learning a language must that have been! —Walking about with the teacher over the farm, in the barn-yard, and in the woods; and learning from him how to speak, in Latin, of all they saw . . . how deeply fixed in the memory must all the usual forms of the language thus become!"[5]

[4] George B. Emerson, Education in Massachusetts, pp. 9-11.
[5] George B. Emerson, Education in Massachusetts, p. 11.

It is not hard for us to see why these early colonists of New England should have given education of so high a standard. The leaders of the first emigration to Massachusetts were the most highly educated men that ever led colonies, and were symbols of independence and love of liberty. "They possessed and long continued to exert, an influence of the highest and noblest kind . . . we may search the world in vain for more conspicuous, unselfish devotion to the cause of what they believed to be truth and the rights of humanity."

I need but mention the advance made by such books as Rolfe and Gillet's (1870), Steele's Fourteen Weeks Series which were in one quarter of the schools, Gage's Elements of Physics (1822), which bore on the cover the words "Read Nature in the Language of Experiment", Avery's (1884), and Paul Bert's First Steps in Scientific Knowledge, the introduction of which caused a stir in the schools. These books are rightly called books of the informational type, but should not be condemned for that.

When natural science was first introduced into the course of studies, algebra and geometry were emphasized. Astronomy followed closely behind, and it in turn brought along natural philosophy, which often absorbed astronomy. Chancellor Brown, referring to this period, writes: "Geography . . . began to be emphasized. . . . There were many interesting things in the text-book, and the subject was intrinsically attractive, besides offering a great store of information."

After the middle of the nineteenth century there was a demand for informational courses. Brown goes on to say that the result "was that 'multiplicity of short informational courses', particularly in the natural sciences, against which the Committee of Ten protested. A group of text-books bearing the titles "Fourteen Weeks in Chemistry and Fourteen Weeks in each of the several other subjects, obtained a wide popularity at this time, and was highly characteristic of the tendency referred to."[6] It would appear that this Committee of Ten formalized and limited those studies which still had some small breadth of freedom.

Henry Kiddle, City Superintendent of New York Schools from 1870 to 1879, fostered the teaching of science. In 1870 he had astronomy taught during the last two years of the grammar school, and had a special teacher give two or three lessons a week in Fa-

[6] E. E. Brown, Making of Our Middle Schools, p. 417.

miliar Science. In 1871, the first two and a half years of the grammar grades gave elementary science—the qualities and uses of familiar objects, clothing, food, materials for building, zoology, botany, mineralogy and hygiene. In the last year and a half natural philosophy and facts in chemistry were offered. From these early attempts it can be seen that Kiddle was trying to give the child a broad survey and at the same time a definite understanding of things vital to him. From his attitude it would appear that he was a forerunner of the movement now on foot. However, when a subject is first introduced into school, it retains much of the outside life characteristic. This may be one of the factors for making the science of Kiddle's day so vital in subject matter. As a subject continues in the school and is twisted to yield to the likings and conveniences of the teacher, its tendency is to become formal. Mr. Harrison, Assistant Superintendent, speaking of natural philosophy in 1872, said: "This subject has evidently awakened a wide and profitable interest in classes and teachers; and considerable progress of a satisfactory character is already manifest . . . A number of teachers still manifest a strong tendency to begin with and dwell upon a series of definitions, instead of teaching the subject objectively. I am encouraged to hope that further experience will lead to the abandonment of a method so ill adapted. . ."

In 1884 the United States Bureau of Education issued a bulletin advocating inductive teaching, simple experiments in familiar units, and training in the scientific method of thinking. Professor Mann says: "These ideas found frequent expression at this time (1884); yet in spite of this, they were not followed in the subsequent development of physics teaching. Now there is a general demand for a reorganization of this teaching in conformity with the ideas that were so prominent twenty-five years ago."[7]

At about the same time, from 1881 on, there was in Boston a superintendent who strenuously opposed formula studies. Seaver believed that the first step in good teaching was an appeal to the observing powers, and that words and other symbols should not be allowed to intervene, tempting the learner to satisfy his mind with ideas obtained at second-hand. He said: "Faraday never used the term gravitation in elementary lectures without at the same time recalling to the minds of his hearers, by letting a stone fall to the floor, or otherwise, a vivid idea of the thing signified by that word."

[7] C. R. Mann, Teaching of Physics, p. 53.

In the report of 1881 he writes: "How many of our text-books begin, not with the suggestion of concrete illustrations, but with abstract definitions, and still more abstract 'first principles'—blind guides to the blind teacher, and sources of perplexity to teachers who are not blind." He advocated cutting the schools loose from one another and freeing them from the necessity of sacrificing the interests of their pupils for the sake of uniformity.

About fifteen years ago, when New York City was consolidated and Maxwell superintendent, there were a great many changes in the course of study. The idea of having special teachers for a particular subject became popular in New York and suburbs as well as in other cities. But teachers assigned to science for instance, knew very little about it. A large number of them sought information at Teachers College. Saturday mornings they gathered here and filled the largest lecture room in the building. At that time the manufacturers of syllabi were even more famous than they are today. The special teacher was given a syllabus which gave every experiment and bit of information in detail.

At about the same time E. H. Hall was doing a similar work at Harvard for teachers of Cambridge and its suburbs. The high school teacher complained that the student who came to him had not the first inkling of science. This brought forth the notion of *preparing* the child for high school science, just as we prepare the high school youth for college science. To carry out this operation Professor Hall took from the high school physics (Hall and Bergen, A Text Book of Physics) the first 178 pages, which apparently were "fundamental", and published them in a book about one-third as large as the high school text, calling it Lessons in Physics. It might have been an advantage to the beginner in science had he been given the benefit of the more interesting padding which the larger edition contains.

The tendency in the direction of general science is seen further in the movement started at Springfield in 1904. Dr. Balliet, then superintendent of schools in Springfield, and Mr. Orr, Principal of the Central High School felt that physics was altogether too quantitative and not closely enough connected with environment; that all the science work was controlled too much by the idea of fitting for college. A new course, a combination of biological and physical sciences was organized so as to appeal to the pupil. This new course, which was carried out by Mr. Russell and Mr. Kelly, drew

its material as far as possible from local environment and from those things connected with the interest and experience of the child; it made most of the experiments quantitative; it aimed to give minimum of principles or laws and a maximum of applications, to give the child power to interpret his physical environment; it purposed to develop interest in natural forces and to show their use in the service of man. The difficulty lay in getting teachers who were acquainted with the larger field of natural science. The success of such a course depends, of course, upon the teacher. Dr. Balliet said recently, "It was found necessary, even in this general course, to have considerable regard to the variety of abilities in the case of individual children. The aim was to find out what the child was interested in and what he knew of the outdoor world, and then the scientific work required of him was closely connected with his own individual knowledge and interest."

In Schools of To-Morrow Professor Dewey writes, "Probably the greatest and commonest mistake that we all make is to forget that learning is a necessary incident of dealing with real situations. We even go so far as to assume that the mind is naturally averse to learning—which is like assuming that the digestive organs are averse to food and have either to be coaxed or bullied into having anything to do with it. Existing methods of instruction give plenty of evidence in support of a belief that minds are opposed to learning—to their own exercise. We fail to see that such aversion is in reality a condemnation of our methods; a sign that we are presenting material for which the mind in its existing state of growth has no need, or else presenting it in such ways as to cover up the real need." During the past decade significant attempts have been made to overcome this seeming aversion to learning. One of the more recent results has been the introduction of the project method in science.[8]

[8] See: Teachers College Record for January and May, 1916. See: "General Science is Project Science", School Science and Mathematics, December, 1915.

General Science in the Normal School

WILLIAM GOULD VINAL, The Rhode Island Normal.

While general science is crystallizing into a definite form the normal school must anticipate as far as possible the requirements for effective work in teaching the subject. The problem of training these teachers demands organization. Is not the time ripe for an exchange of ideas? The writer feels that he has far from solved the problem but he ventures a presentation of some of the general science ideas which are formulating in his mind. It is recognized that no two normal schools should have the same course but it is hoped that the Quarterly will be a medium for the exchange of ideas. This might lead to a meeting for the discussion of the principles involved and for the purpose of fitting our ideas into a consistent, practical course.

The course in general science in the Rhode Island Normal School is given to first year pupils who have had both physics and chemistry in the high school, which means over 80% of the enrollment. The course consists of two fifty minute periods and one double period for twenty weeks. The double period is for the purpose of laboratory work, supervision in methods of study, library research, and outside trips.

General Science in Daily Life. The fundamental value of general science is proportional to the realization of the pupil that it relates to the tasks of daily life. The supreme value is in the application of scientific methods and experience wherever the occasion occurs. This gives a pleasurable quality to what is oft times mere drudgery, and thereby leads to higher thoughts and ideals. Every teacher should be trained to examine the field of science in the homes of his pupils in order to appreciate its relation to life and secondly as a basis for organization of the course of study.

The normal school girls were asked to make a list of things that they did in one day that were related to science. Nearly every one poured hot water and potash down the sink to clean out the traps. The class had been studying the plumbing of the household. The only scientific thing that one girl did was to wash the dishes and make candy. Another washed her face and hands with soap, brushed her teeth with tooth powder, washed the dishes, lit

the gas stove, baked a cake, cleaned the silver, rang the doorbell, rode in an electric car, etc. No one else mentioned washing her face and hands. Science teachers, themselves, have not agreed as to the scope of science. Is cleanliness and the action of alkali soap on the oil of the skin good science? This lesson formed a good basis for discussion and to some extent for clarifying the conception of science, if not technically, at least for all practical purposes in general science.

The Scientific Method. The scientific method is a difficult one to analyze. It is an attitude of mind. The starting point is facts. Facts are collected by means of all the senses, first hand. From several observations one may draw a conclusion. This conclusion should be tested. This stimulates further observation. The success of this method of thought comes when the pupil applies these steps, unconsciously, outside of the school room.

The teacher should not create exercises for the purpose of giving the student this line of logic but when the opportunity for the cultivation is offered this method should be used.

To train teachers not only to recognize but to acquire the scientific method is a difficult problem. The normal school students meet this experience through experiments. They are required to teach experiments before the class. Four steps are recognized: method, observation, conclusion, application. The experiment is usually demonstrated by the student teacher and the four steps are recognized and explained by the class. Different types of assignments led to the same aim, as—

a. The Fireless Cooker. Discover what the principle is on which the fireless cooker is based. Prepare a simple experiment to introduce the principle. Bring out other applications of the principle.

b. Atmospheric Pressure. Prepare to present a simple experiment which teaches something about atmospheric pressure. After several experiments have been taught give the class a short time to plan to teach the general laws concerning atmospheric pressure. Some facts are to be told by the teacher (as, 15 pounds to the square inch); some facts are to be told directly by the pupil (as, the atmosphere presses in all directions); and others are to be taught (as, the variation in pressure due to temperature.

The first exercise begins with the principle and the second ex-

periment ends with the general law. One is deductive and the other inductive. Both methods are good science.

Community Projects. It is highly important that the youth of a community should know what the science problems are that are supported by that community. They should know the nature of the work, the results, and their own responsibility as citizens. The difference between intelligence and ignorance as to the support of these issues is comparable to the difference between the seeds of anarchy and of good government. This need may be recognized in many directions, as—the Board of Health, Housewives' League, District Nursing, Sanitary Milk, Public Market, Arbor Day, City Museum, Board of Recreation, Municipal Baths, Metropolitan Park System, Good Roads, City Play Grounds, Good Harbors, Clean-up Campaigns, Fire Department, Sewerage Disposal, Water Supply, Chamber of Commerce, etc.

The pupils were asked to select one of these projects for individual study, the results of which were to be presented to the class. They were asked to make a bibliography of the literature in newspapers and magazines which was related to the home question, to visit these places whenever possible, to obtain any literature issued by the department, and if feasible to plan a little exhibit to make clear the report. The class found great pleasure in the pursuit of this data. The reports and class discussions were eminently worth while. Above all was the importance of opening a doorway to the teacher of the possibilities and responsibility of teaching children the "hygiene-preparedness" of a great city and its sociological factors. Thinking in terms of city or state is particularly wholesome in times of warfare.

Individual Projects. Much has been written of late concerning the project method. The teacher's part may be summed up in three words,—material, stimuli, and guidance. Here the "Divine right of Teachers" endeth and the "Divine right of the pupil" beginneth. Treat the pupil as a man or woman, and remember the old adage that "Every child's got to do its own growing". The teacher who is accustomed to the Cook's Tour method of treating a subject will be uneasy at this stage. To keep thirty individuals of a class absorbed in thirty profitable undertakings and to guide them into the higher forms of their own natural activities is a high ideal. I must confess that I have not attained that develop-

ment and hence have been unable to make it practicable for others. Success has been reached in some individual cases, however, and a summary is given of a few of them.

1. The senior class had been on several bird trips in the spring. Imitations of the bird calls had been practiced. One of the class reported that Miss —— was whistling bird calls to groups of girls in the cloak room. She was called to the office. Decided to take this as a special topic. Excused from the regular assignments. She gave a talk on birds, and imitated their calls, on the programme for Arbor Day. She was asked to speak to the Camp Fire Girls in a neighboring city. In order to perfect her talk she went to the Park Museum and to the teacher of oral reading. The whistling led to a deeper interest in music. She purchased a camera and took pictures of birds. This led to a desire to make lantern slides for her talk. She attended all bird lectures in the city. All this took place in eight weeks. The results were manifold as compared with the possibilities from sixteen lessons in nature-study.

2. A normal school girl just starting in practice-teaching in a training school in an insanitary district. Nature-study became centered on the house-fly. Neighborhood began to clean-up. She went into city training. Formed a fly club. The children obtained the Board of Health Bulletins and made fly traps. Student teacher went to Washington in the summer vacation and while there visited the Department of Agriculture, the Division of Entomology, and the Smithsonian Institute. An exhibit was prepared for the State Teachers' Institute. She contributed valuable material to the exhibit and was asked to give a lesson on the fly before the Institute. She was soon elected to an important position. She has written an article on the work which is to appear in a well known school publication this spring.

3. A girl was excused from regular routine work to organize a Camp Fire group. She trained herself to become efficient in the field. Had the girls give an entertainment to get costumes. Picked poison sumach, in its autumn colors, to decorate the hall. She, and several girls were poisoned. Had been taught in class how to recognize this plant. Now has a better reason for remembering its characteristics. Gave a pageant to obtain money for summer outing. Girls went to camp for a month. Learned out-door cooking, swimming, etc. Gave an entertainment which included folk dancing and singing and had a float in old home week parade.

This chosen work has been equivalent to a course several years long in the class room.

4. Took charge of the Audubon Exhibit at the Food Fair. Asked to tell experiences before the Audubon Society. Became interested in this line. Volunteered, and given charge of the Lowell Astronomical Exhibit at the Roger Williams Park Museum. Has a position in a girls' camp for the summer. Has decided to attend the state college.

Bibliography. One method of solving questions that arise day by day is by referring to a book. It may be a medical book, a cook book, a garden book, the Old Farmers' Almanac, etc. The more momentous the problem the greater the pre-requisite for reading. Until general science becomes better organized and the text a reference hand-book, the teacher must search out her material in magazines, reports, the proceedings of learned societies, and specialized books of all kinds. This necessitates training in this line. Certain phases of general science readily lends itself to this sort of work. The topics should be numerous to insure individual work. They should not be given merely for the purpose of making a bibliography.

The following assignment proved rather valuable in this line: A list of soils, minerals, metals, and rocks, was written on the board. The pupils were asked to sign their name opposite one which interested them. Only one pupil could work upon any one topic. They were told that this was to be a test in efficiency of obtaining and organizing material. The following method of organization was explained to them as a type.

SAND.

Uses	*Adaptations*
Sandpaper	hard, rough, fine.
Filtering	clean, not easily dissolved, fine.
Hour Glass	uniform size, fine, clean, durable.
Icy sidewalks	rough, fine, hard, cheap.

The class were then given one period to work upon their selected topic. The references read were listed as a bibliography at the beginning of the paper and as fast as uses were discovered they were added to the table. An incomplete fact from one article might be found in another source and other writings were useless

for the particular occasion. It was valuable training in finding sources, rejecting unsuitable articles, in sorting out facts and arranging them. The papers were passed in and graded comparatively according to the number of points and references made. In this way one pupil might compare her own standing with the average and also the highest of the class.

The study of the bibliographies of scientists is also a good opportunity for this sort of work. This is better for outside research however, as it gives a pupil opportunity to visit other libraries and to study the topic at length. The variations of the class in stick-to-it-iveness could be plotted at this time, and some of those who were below the average in the last lesson might experience the stimulus of excelling in this line.

Biography. The study of great authors and famous generals has become a matter of course in school lessons. In science little attention has been given to this aspect. Although not essentially a part of the subject-matter, I feel sure that the biography of scientists is interesting and profitable. A list of the great contributors to scientific knowledge and their special achievement was written on the board, such as,—Harvey, Circulation of the Blood, 1616; Galileo, telescope, 1609; Schleiden, Cell Theory, 1838. The pupils were told to select one by writing their name opposite that of the scientist. The class were told that these men used the project method. They had a vision of something to be done and set about to do it. The method of study was: (1) Read the biography; (2) Pick out the steps and influences which led to the invention or discovery; (3) How can this study help us in teaching?

The class reports proved most interesting. They learned for instance, that Edison was a poor boy who earned money selling newspapers on a train. He overheard his teacher speak of him as a dunce and this spurred him on to "do things." One day when some of his experiments were upset on the train the conductor "boxed Edison's ears" which made him deaf for life. These reports gradually led the class to appreciate the hardships and many discouragements under which men who do things worth while have worked. They were usually without money and often poor in health. These student-teachers saw rather forcefully that the project method may bring something very much worth while for the backward boy or girl and also realized the great responsibility of a

teacher when she might suppress an Edison or when she might lead him on as would the great teacher in science, Louis Agassiz.

Magazines. The reading of science articles in magazines is supplementary and not anticipatory to the science lesson. The class room gives the proper foundation or stimulus. A thunder shower may occasion a discussion in regard to lightning. The many superstitions would probably lead to the desirability of reading. The teacher might refer to the article on lightning in the General Science Quarterly for November, 1916. Other articles in the same magazine might be prepared for class discussion, as,—Why Science in the Grades? Sharp debates follow the report of the article. This develops personal power. Help the class to decide whether the writing is acceptable. How is it related to previous class work? What can be done to test it out? What new information is necessary? The most up-to-date text in general science that a normal school class can have is the General Science Quarterly. It gives them points of contact with present day teaching in science. They begin to realize that general science is essentially different from book-work courses. They feel free to disagree and to test. Such a study does much to broaden the horizon of teachers of general science.

An Illuminating Gas Project

By J. Richard Lunt, English High School, Boston.

During the past four years an Illuminating Gas Project has been included in the General Science Course at the Boston English High School. The following problems have been selected:

1. How Illuminating Gas is Made.
2. Composition of Illuminating Gas.
3. Properties of Illuminating Gas.
4. How Illuminating Gas Burns.
5. The Gas Meter and How to Read it.
6. The Gas Range.
7. Gas Lighting: Open Burners: Mantle Burners.

The whole project requires about thirty periods of forty minutes each. The work is entirely experimental. Practically no information is supplied. Conclusions are derived through questions based on experience. The general plan may be illustrated by the

problem, "Mantle Burners." For the first lesson the Junior Welsbach is selected as one of the simplest types of upright burners.

I. *Home Study.* Examine any upright mantle gas burner. Note the different parts. How do you adjust it? Why does this mantle give light? Effect of too much gas? Too much air? Do you find any black soot? What is it? Where does it come from? How can you prevent it? Does this burner make a roaring noise? What is the cause of this?

II. *School Study.* 1. Take apart a Junior Welsbach Gas Burner. Examine and describe the nipple, cap, burner shaft and mantle.

2. Screw the nipple to a gas fixture. Open the gas cock. Ignite the gas. How does it burn? Why are there two flames? How do you explain the color of the flames?

3. Screw the cap on to the nipple. Ignite the gas. How does it burn now? Why is there only one yellow flame? Turn the cap up. What happens? Turn the cap down. What happens? How do you account for this? What part does this cap play in the Junior Welsbach Burner?

4. Screw on the burner shaft. Ignite the gas. What color is the flame now? Why has it changed from yellow to blue? What is the shape of the flame? Why is it conical? Hold a smoking joss stick near the air ports. What happens? What does this prove? Show all the places where air is supplied to this flame. Hold a porcelain dish in the flame for about a minute. Hold the porcelain dish in the yellow flame. What happens? How do you explain this? Turn down the cap. What happens? What causes this back firing? Where is the gas burning now? What is the use of the wire screen? What do you infer in regard to the relative amount of air and illuminating gas needed for complete combustion? Prove your statement. Does the blue flame give as much light as the yellow flame? Why then, is it used in mantle burners?

5. Put the mantle on the burner shaft. Hold a burning match near it. What happens? What is this? Why is it used? Turn on the gas. Hold a burning match just above the mantle. What happens? Why does the mantle give such a bright light? Would a mantle made of iron wire give light? How is this mantle made? Why is it so fragile? Why does it glow brighter than iron?

6. Put on the globe. How does the light from the bare mantle

effect the eyes? How do you account for this? Is the brightest light always the best? Try to read a book facing this light. Now turn back to the light. Which is the better position? Why is the globe used? Does all the light come through the globe? How does it affect the eyes to look at the light now? What kind of a shade would you use to throw the light down? To throw it up? To give a general illumination?

7. Try to adjust the gas so that the mantle gives its best light with the smallest gas consumption. Turn down the cap until the light grows dim. Now turn up the cap until the best light is obtained. Turn the cap up higher. Does the mantle give any more light? Why not?

8. Attach the Junior Welsbach Burner to a Minute Observation Sweephand Meter.

RESULTS FROM ACTUAL TEST.

GAS BLOWING	ADJUSTED
Consumption per hour = 4 cu. ft.	Consumption per hour = 2 cu. ft.
Cost per hour = $0.0032.	Cost per hour = $0.0016.
Time for 1 cent = 3 hrs. 7 min.	Time for 1 cent = 6 hrs. 14 min.
Cost for 1000 hours = $3.20.	Cost for 1000 hours = $1.60.

The following statistics may be of some interest. These represent the testimonials of 648 boys:

Total number of boys reporting	648
Number using Illuminating Gas	542
Number using Electricity	61
Number using Kerosene Lamps	45
Number using all Open Burners	287
Number using Open and Mantle Burners	182
Number using all Mantle Burners	73
Number using Gas Ranges	316
Number using Gas Hot Plates	94

Changes reported one month later:

Mantle Burners substituted for Open Burners	712
Adjustments of Mantle Burners	321
Adjustments of Gas Ranges	85
Reductions in Gas Bills from 5% to 60%	336
Total reduction reported for one month	$128.00

Introductory Fire Lesson

By R. H. Williams, Horace Mann School for Boys, New York.

To give a word picture of an actual science recitation is a difficult undertaking. Even a stenographic report of such has, as a rule, the appearance of unreality. This must necessarily be, for many of the factors by which we judge a lesson are evident only under actual recitation conditions. The play of personality, the general class interest, the use of experiment and its execution and reaction on the class, are vital features of a recitation; but these do not find expression on the printed page. It is, however, a fact that many teachers desire suggestions as to a more pointed and direct method than appears on the pages of a text book. A science text, however meritorious, can give little more than subject matter. Of course, to get the real essence of a method for presenting a topic one must observe that method in action. But, however subtle a thing method may be, it probably cannot entirely escape description.

In what follows, an attempt is made to show how the first lesson on "Fire" is actually presented to a class. Not all the details of every line of discussion is given. The aim is, however, to give as concrete an illustration as possible within a limited space, of "how" as well as "what" is presented in an initial lesson on this important topic. The lesson begins with (1) a rather general discussion of the topic. This leads to the consideration of (2) a particular question or problem.

(1) Informal discussion on the uses of fire:

The discussion is usually opened by a question as,—"How would you like to live in a world where there were no fires?" or "What inconveniences would you experience if there were no such thing as fire?"

The justification of this form of question is that it has proved more thought provoking than the usual request for the enumeration of the uses of fire; it is a sharper challenge to the pupil's intellect; it is a little more novel to the child and therefore, perhaps more worth while to him. The great stock question demands of the pupil an enumeration, a telling or reciting of something rather than the giving of an opinion resulting from a mental analysis, how-

ever simple. This is not an argument for doing away entirely with the "memory question." We can never entirely abolish it so long as our present organization exists, and boys and girls are as they are. But a generous sprinkling of another kind of question is a desirable class stimulant.

The purpose of the eight to ten minutes introductory discussion is to give the class a renewed sense of the importance of fire and to lend dignity to our topic.

(2). Consideration of a question (problem), (project).

Teacher. "Important as fire is, and familiar as many of you are with it, I doubt if you could tell me just how to build one and why you build it as you do. In order that we may consider this matter very carefully, I'll put the question on the board.

How do you build a bon-fire?

Let us assume that we have here in front of the class a boy who is about your age; who has attended schools such as you have; who has lived and played as you have; who has had all your experiences with the exception of an acquaintance with fire. Of fire, he knows nothing. Now give him directions how to answer this question on the board."

Pupil. First you must get (1) matches; (2) paper, shavings; (3) coarse wood, and they must all be dry."

Teacher. "Are these arranged in the order of their importance? Suppose you were told that you could have one of these, and that you must supply the other two. Which one would you ask for and why?"

Usually an interesting discussion develops about relative values, and in life there are many situations in which judgments as to values must be made. No argument is needed, therefore, to justify an opportunity to think about values, to form judgments concerning them, and to point out differences in the values of things seemingly equal. A class of city children, in answering this question, brings out the difficulty of procuring coarse fuel, the ease with which fine fuel (shavings) may be made, and the fact that matches may be dispensed with.

Teacher. "Having, now, these three things, has this strange boy sufficient information to proceed?"

Pupil. He must learn how to place the materials. (1) He must make a little pile of the shavings and then put a little coarse fuel on top. (2) If there is a breeze, he should place the shavings on the

wind-ward side. (3) Then, he must strike the match and apply it to the shavings."

Teacher. "In case there were no breeze, or, if a very strong wind were blowing, he might experience difficulties. What would you suggest?"

Pupil. "He should fan the fire in the first case and shield it in the other."

Teacher. "This is a very inquisitive boy. He wants to learn, and you can imagine how very mysterious all this is to him. Now, look over the directions for building a bon-fire as we have it on the board, and tell me what questions this boy would naturally raise?"

Pupil. (1) "Why do you need dry fuel?"

Teacher. "Explain it to the young man."

Pupil. "Because wet fuel won't burn."

Teacher. "But the boy asks why it won't burn? The wet shaving doesn't know it's wet, neither does the match flame as you apply it. Then why doesn't it burn?"

Pupil. "——? ——?"

Teacher. "This you cannot answer just yet. But we'll answer it and other questions which this boy would ask just as soon as we have a complete list. These questions I'll place on the board. What are they?"

Pupil. (2) "Why do we need fine as well as coarse materials?"

(3) Why do you use wood and shavings for fuel rather than sand, sod and stones?" Why don't these things burn?"

(4) Why do you put the fine fuel under the coarse; and why on the windward side if there is a breeze?.

(5) How does striking a match light it?

(6) How does fanning a fire aid it if there is no breeze?

(7) How is it that a strong breeze puts out a small fire?

(8) Why must you use a match or live coals to start a fire? Why doesn't it start without them?"

If the pupils have had no previous training in science, satisfactory answers for these questions will not be forthcoming. Just why a particular and familiar process gives the desired result, is not clear to them. Needless to say, this list of questions which a class will raise is not complete. It does embody, however, the main ideas which, if made clear, will give the pupil an insight into the rationale of fire extinguishers, the different methods of attacking fire, fire prevention measures, and the like. Having the

list, the teacher arbitrarily picks out one question which is fundamental and proceeds to its consideration.

Teacher. "We'll discuss first question No. 6. 'How is it that fanning a fire aids it?' I am ready to consider any suggestion you may make in answer to it."

Pupil. "Fanning a fire gives it more air."

Teacher. "I would accept your suggestion as a reasonable one if I were sure that a fire needs air. But does it?"

Pupil. "I have put out a small fire by placing something (tin pan, sand, etc.) over it so it couldn't get air, so I think air must be needed."

Teacher. "But there was some air at least in the tin pan or whatever you put over the fire."

Pupil. "But there was not enough. Fire needs fresh air all the time."

A simple experiment with candle and drinking glass is made, if the pupils need this experience before they will accept as the most probable answer to the question the suggestion offered.

This is the general plan of every attack made upon a question, problem, project or perplexity of this type. It consists of a definite statement of the question, a suggestion or guess as to the answer, and a consideration of this suggestion.[1] If it agrees with and supports previously accepted facts, the suggestion is accepted; if not it is rejected.

Teacher. "Criticize our original list of essentials for a fire."

Pupil. "Air must be added. Things necessary for a fire are (1) fuel; (2) matches; (3) air."

Teacher. "Question No. 5. How does striking a match light it?"

Pupil. "Friction lights the match."

Almost every child has this question in his earlier years, and if his memory serves him, his answer is "friction",—a term which has no very definite meaning for him.

Teacher. "Friction is the act of rubbing one body over another,—then your answer is "the act of rubbing lights it." But if I rub it between my fingers or draw it (slowly) across this surface, it doesn't light."

Pupil. "But you don't rub it fast enough."

Teacher. "Then it isn't the mere act of rubbing that lights it?"

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[1] Dewey's How We Think, Chapter VI.

Pupil. "No, you can light it without any rubbing. Touch a flame or hot stove with it."

Teacher. "But fast rubbing does something for the match which slow rubbing will not do. What is it?"

Pupil. "Fast rubbing makes heat. If you slide down a rope, or draw your finger across a table top, heat is made and you can feel it."

Teacher. "Then, what is your final answer to the question on the board?"

Pupil. "Striking a match makes heat, which lights it."

Teacher. "How is it that a piece of wood does not light when you strike it as you do a match?"

Pupil. "There is something in the head of a match which makes it light."

Teacher. "If the tip makes it light, why doesn't this match, which has a good tip, light?"

Pupil. "Because you havn't struck or heated it in any way."

Teacher. "Then what is the immediate cause of the lighting?"

Pupil. "Striking or heating it,—not the fact that it has a tip."

Teacher. "Again, why doesn't the wood light when I strike it? Do I not heat it? Even if I touch this hot plate with it, it doesn't light."

(Suggestion from experiment). Place on an asbestos board a small piece of phosphorus, lump of sulphur, and bundle of wooden tapers. Warm a glass rod and touch in turn the tapers, sulphur, and phosphorus. The rod, just warm to the hand, lights only the phosphorus. By increasing the temperature of the rod, the sulphur may be kindled, and finally the tapers.

Teacher. "If you were told to manufacture a match, what would you ask for and why?

Pupil. "Phosphorus, because it lights so easily. It takes but little heat to light it."

Before leaving the discussion of this experiment, an attempt is made to give the pupil the fact that each substance has a definite temperature to which it must be heated before it will kindle. This kindling temperature, while fixed for each substance, varies greatly for different substances. The answer to the original question,—"Why doesn't wood light when you strike it?" is then elicited.

Teacher. "The essentials for a fire as given so far are: (1)

fuel, (2) matches, (3) air. I want to change (2) so that it expresses exactly what we mean. We all know we can build a fire without a match."

Pupil. "We must have heat."

Teacher. "But how much heat?"

Pupil. "Enough to raise the substance to be set on fire to its kindling temperature."

Teacher. "Then the essentials for a fire are: (1) fuel, (2) sufficient heat to raise the fuel to its kindling temperature, (3) air. These are the supports upon which every fire rests. In this respect, a fire is quite like a three-legged stool. If one leg of such a stool is removed, we know what happens; and it doesn't matter which leg it is, the result is the same. If one of the three essentials for a fire is missing, the fire won't "stand up." Whatever you do to a fire, stop or start it, increase or check it, you do by affecting directly one of these essentials.

Now we are ready to consider the statement of a well known fact and to offer an explanation,—wet shavings do not burn, or do not burn so well as dry ones. Keeping in mind the essentials for a fire, locate the difficulty."

Pupil. "It can't be lack of fuel, for the shavings are there, although wet. Air also is present in and about the wet fuel. It must be because wet fuel can't be raised to its kindling temperature as readily as dry fuel." [Answer now the first question.]

Teacher. "If you wanted to dry damp shavings quickly, what would you do?"

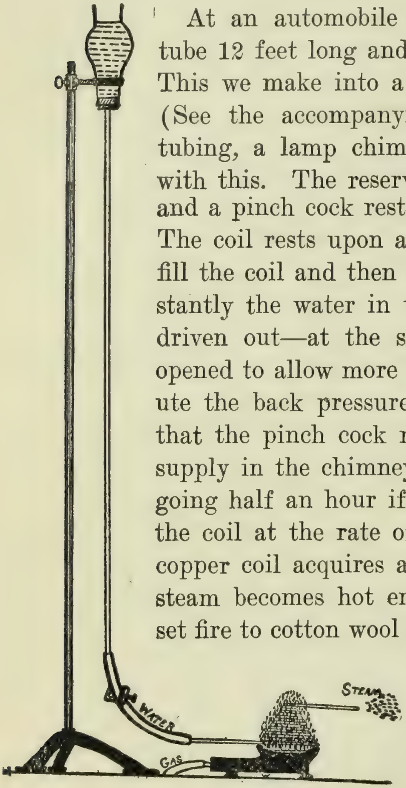
Pupil. "Put them in an oven,—heat them."

Teacher. "It takes heat then, to dry wet shavings. If I wet this taper and then hold it in the flame of a bunsen burner, you observe that it dries first. All the heat it gets from the flame is used for this purpose only. Once it is dry, however, the heat is able to raise the taper to its kindling point, and it burns."

Now you have enough science to answer at once questions (2) and (4).

An Experiment with Superheated Steam

By JOHN F. WOODHULL, Teachers College, Columbia University.



At an automobile supply house we procure a copper tube 12 feet long and one quarter of an inch in diameter. This we make into a coil by winding it around a bottle. (See the accompanying figure). By glass and rubber tubing, a lamp chimney reservoir of water is connected with this. The reservoir is raised 4½ feet above the coil and a pinch cock restrains the flow of water until needed. The coil rests upon a gas stove. The water is allowed to fill the coil and then the gas stove is lighted. Almost instantly the water in the coil is converted into steam and driven out—at the same time the pinch cock is slowly opened to allow more water to flow. After about one minute the back pressure of the steam restrains the flow so that the pinch cock may be wholly removed. The water supply in the chimney will suffice to keep the experiment going half an hour if desired. The water passes through the coil at the rate of about two drops per second. The copper coil acquires a red heat in a few minutes and the steam becomes hot enough to char paper, light matches, set fire to cotton wool and light a cigar.

"A man may have a good deal of cultivation, a good deal of information, correct information at that, about things, but if he has never made a first hand acquaintance at some point with scientific ways of dealing with a subject matter, he has no sure way of telling the difference between all wool knowledge and shoddy goods."

—*Dewey*.

The Present Status of General Science in High Schools in Pennsylvania

By John H. Rusterholtz, Chicago, Ill.

As a part of my work in Science in Education, I have endeavored to determine the present status of general science courses offered by the high schools of the first grade in the State of Pennsylvania. This work is a part of a series of co-operative studies which are being conducted by the present or former students working with Dr. Otis W. Caldwell. The following questionnaire was sent to all principals of high schools of the first grade, as classified by the State Department of Public Instruction for the school year ending July 1st, 1915:

"Dear Sir:—

In connection with investigation in "Problems in Science Teaching", now being carried on by students in the Department of Natural Science, University of Chicago, I wish to obtain information regarding the work in general science in the public high schools of Pennsylvania. This investigation is a continuation of similar work done in Iowa, California, and Massachusetts, a report of which was published in "School and Society", July 29, 1916.

I should like very much to have your opinion regarding general science, even though you do not offer the course in your high school. I realize that it requires valuable time for you to give me this information, but the questions involved are of such importance that it will be helpful indeed, if you will supply the needed data."

"Is general science taught in your high school? When was it introduced? What subjects, if any, were displaced by it? What text book is used? Is laboratory work given? Is field work given? Time, in weeks?——Hours per week?—— Year when course is given? 1st, 2nd, 3rd, 4th. Are pupils from other years allowed to enter the class? What other subjects are taught by the general science teacher? What has been the preparation of the teacher in the field of science? What other science courses are offered in your high school? 1st year——— 2nd year——— 3rd year——— 4th year———.

Please give briefly your own opinion of the value of a general science course."

The writer takes this opportunity to express his appreciation of the co-operation on the part of the principals reporting. Without such co-operation the data available would not have been complete nor so reliable. If this report serves in any way to increase interest in and definite knowledge about the science work of the freshman year of the high school or in the science of the junior high school, it will have accomplished its purpose.

For convenience in comparison, the schools of different sizes have been divided into the groups A, B, C, and D, according to enrollment. Group A includes all schools having an enrollment of 500 or more. Group B represents schools of 200 to 500 pupils. Group C represents schools having 100 to 200 pupils. Group D less than 100 pupils.

A total of 298 letters was sent to principals, as may be seen in Table I, as follows:

TABLE I

	A	*B*	*C*	*D*	*Total*
Principals to whom letters were sent	39	57	112	90	298
Principals reporting	36	49	88	50	223
Schools offering general science	25	22	49	20	116
Cases where subjects were displaced by general science	11	15	36	15	77
Cases where physical geography was displaced	8	12	34	13	67
Number of schools offering laboratory work	9	19	37	19	84
Number of schools offering field work	12	16	24	8	60
Schools offering full year courses in gen. sci.	24	17	39	16	96
Schools offering 16 to 24 weeks to gen. sci.	1	5	10	4	20
Cases where general science is given in 1st. yr.	25	22	47	20	114
Schools having college graduates teaching general science	21	22	40	18	101
Schools having teachers who teach general science only	8	1	3	0	12
Schools having teachers who teach general science and other sciences	15	17	36	16	84
Schools having teachers who teach general science and subjects other than science	2	4	10	4	20

Of these 298 principals, 223 reported the position of science teaching in the schools with which they are connected. General science is offered in 116 cases, leaving 107 schools which offer no general science courses.

It is interesting to note the relation between the number of cases where subjects have been displaced by general science, and

the number of cases where physical geography is the subject displaced. This may mean that physical geography has not been dropped from the curriculum as a separate subject, but has been incorporated in the course of general science.

The total number of cases (84) where laboratory work is given includes both laboratory demonstration by the teacher and individual work done by the pupil. In many cases where little or no laboratory work is given, principals reported that such work would be given as soon as equipment and space could be provided for it, and similar statements were made regarding field work.

Of the 116 schools offering general science, 96 offer a full year course, while the remaining 20 schools devote from 16 to 24 weeks to the subject. There is some variation in the amount of time per week devoted to the subject, but in the majority of cases 3 or 5 hours per week is given.

The 114 schools offering general science in the first year include a few cases where it is given in the junior high school. This may, or may not, mean the first year of the junior high school, the data not being clear on this point.

College graduates are teaching general science in 101 schools, and of these teachers many have specialized in science and have done graduate work. Of the schools considered, 12 have teachers who teach general science only, 84 have teachers who teach general science and other sciences, and 20 have teachers who teach general science and subjects other than science.

It is encouraging to note the number of principals favoring general science, even where the subject has not been offered. The distribution of the number of principals favoring, opposing, or expressing no opinion, may be noticed as follows:

TABLE II

Summary or Opinions by all Who Favor General Science

A step in the right direction (1). A good thing (3). Expect it to be valuable (1). Stimulates more intensive study (1). A good movement (2). A very good idea (2). Splendid (1). Lays a good foundation in scientific method (11). Prepares for later science (18). Introduces pupils to a knowledge of what is meant by science (3). Has value when taught by teachers who are broad enough to recognize that general science is general science and not

general physics or general chemistry (1). A most valuable course (7). An advantage in vocational work (3). Excellent (6). Keeps pupils in school (1). Very broadening (3). Most important in curriculum (3). Offers an opportunity to those who do not continue in science and fills the needs of those who leave school early (9). Well disposed to the subject (2). Keeps pupils interested (4). Great value (6). Gives a pupil a chance to find himself (1). It gives the students "fountains of living water to drink from" (1). Better understanding of pupils environment (2). *The* subject of the freshman year (1). Appeals to 15 year old boys and girls (1). More benefit than chemistry or physics (1). Most practical science course in the high school (1). I approve of it (2).

TABLE III.

PRINCIPALS OFFERING GENERAL SCIENCE BUT NOT FAVORING IT.

Do not believe in scientific medleys (1). Little or no value (2). Seems like a hodge podge (1). Too general (1). It tries to cover too many things and not one thing well enough (1).

TABLE IV.

OPPOSITION BY PRINCIPALS WHERE GENERAL SCIENCE IS NOT OFFERED.

Have not seen the theory justified (1). I do not value it where other sciences are offered (1). No value (2). Not worth while (1). No good (1). Too general (1). Hinders rather than helps other science (1). Am not favorable to it (2). Not practical for small high schools (1). Until a more favorable text is brought forth I am not in favor of it (2).

Table V will show how rapidly the high schools of Pennsylvania are adopting general science.

TABLE V.

DATE OF INTRODUCTION OF GENERAL SCIENCE.

1899	1	1912	6
1906	2	1913	6
1909	2	1914	19
1910	2	1915	30
1911	4	1916	43

Table VI is a summary of the position of the sciences where general science is offered.

TABLE VI

General Science	is offered in 116 schools.
Physics	is offered in 114 schools.
Chemistry	is offered in 103 schools.
Biology	is offered in 66 schools.
Botany	is offered in 49 schools.
Physical Geography	is offered in 41 schools.
Zoology	is offered in 29 schools.
Agriculture	is offered in 16 schools.
Domestic Science	is offered in 10 schools.
Physiology	is offered in 6 schools.
Sanitation	is offered in 5 schools.
Bacteriology	is offered in 1 school.
Geology	is offered in 5 schools.

General conclusions may be formed from the above data as follows:

1. Of a total of 298 high schools of the first grade about 75% reported.
2. Of the schools reporting 52% are offering general science courses this year.
3. Of the schools in which general science is taught over 66% have displaced other courses by general science.
4. Of the courses displaced 87% are courses in physical geography.
5. Of the schools offering general science 72% provide laboratory work, and 51.7% provide field work.
6. Full year courses are offered by 82.7%, while 17.2% offer only 16 to 24 weeks to general science.
7. The course is offered in the first year by 98.3%.
8. College trained teachers to teach general science are provided in 88% of the schools.
9. Of the 116 principals 84.5% favor general science, about 11.2% express no opinion and about 4.3% oppose general science.
10. About 65.4% of the principals of high schools in which general science is not taught pronounce it valuable, 13% oppose it, and 21.5% express no opinion.

General Science Bulletin

(*Continued from page 188*)

BY MASSACHUSETTS COMMITTEE

Why are magnets painted red?

Does lightning strike twice in the same place?

Why are not city houses more generally protected by lightning rods?

How often does lightning strike?

Why does frost strike the low lands first?

Why does water "steam" on a cold morning?

Do fish breathe?

Why is it necessary to change the water in an aquarium?

The top of a mountain is nearer to the sun than its base. Why is it colder at the top?

21. Units actually used in a high school course in general science, as shown by a pupil's notebook.

A. The weather.

Experiments.

How heat affects water and air. How a thermometer works. Does the air weigh anything?

Interpretation projects.

Aneroid barometer and how it works. The weather map. Condensation of moisture.

Construction project.

Weather observations and records for one month.

Topics.

Rain cycle. New England weather.

B. Bacteria.

Construction project.

How to plant a bacteria garden.

Interpretation projects.

A study of yeast.

Study of bacteria gardens. (*a*) From dust. (*b*) From a decayed tooth. (*c*) From a toothbrush. (*d*) From a sneeze. (*e*) From a cat's hair. (*f*) From carpet sweepings.

Topics.

Bacteria.

The fly problem. The milk problem. The tenement-house problem.

Demonstrations.

How bacteria look through a microscope.

Germicides and their action.

C. Water.

Topics.

How Boston gets its water (this topic includes construction projects). How the water comes from Chestnut Hill. How to save water. How heat and cold affect water (includes an experiment).

Interpretation projects.

How water is measured and distributed in my home. How to read a water meter. Why water is useful. How water regulates temperature. Water pressure. How to save water.

Construction project.

How water furnishes power (use of water motor). Water pressure and elevation.

Demonstrations.

How the water meter works.

Distillation.

Experiment.

What water is composed of.

D. Electricity.

Construction projects.

To make a wet cell. How to wire your house for electricity. To construct a bell system.

Interpretation projects.

A dry cell. The telegraph. The telephone. The dynamo. The electric motor. The above includes some construction projects, namely, drawings. The electric meter and how to read it including drawings. The electric bulb.

Topic.

The school-lighting problem.

Demonstration.

How electricity is measured.

Electricity *v.* illuminating gas.

E. Combustion.

Interpretation projects.

Study of fuel. Stove. Observation of a wood fire. How my kitchen is warmed. How heat travels. Our science room. The boiler room. Steam. Water pump. Steam-air pump. How cold and hot air come to the mixing fan. The mixing fan. Study of gas burners, including costs. Welsbach burners. Various gas mantles.

Construction projects.

How to make a fire burn fast. How to check a fire. My gas stove. How to read a gas meter. Cook by gas.

Experiments.

What becomes of wood if it is burned? What smoke is. How coal burns. Study of blue and yellow flame. How illuminating gas is made. Properties of illuminating gas.

Topics.

Combustion in the human body. Generalization summary of combustion.

Hot-water heating systems (includes construction projects).

How illuminating gas is made in Everett.

Qualifications of a Teacher in General Science.

The teacher should be widely versed in science, but his knowledge need not be exhaustive in any particular field or subject. A specialist in science is not necessarily a good teacher for boys and girls in their teens, as such an instructor is likely to emphasize subject-matter and not consider the pupil's needs and limitations. The teacher should be competent to gather material from actual observation and experience as well as from lectures, laboratory exercises and books.

A desirable equipment is an alert, active interest in the natural environment, coupled with the habit of keen observation.

The purpose and capacity to organize and use material gained from the environment are important requisites. A teacher who mechanically and slavishly follows routine classroom methods, and depends upon books and laboratory exercises for material, often of so theoretical and abstract a character as to isolate the pupil

from real situations and to beget a distaste, not to say contempt, for knowledge gained by direct observation, defeats the main purpose of this subject.

Many persons well versed in scientific theory and generalizations are at the same time unobservant and ignorant of facts of everyday life. The great names of science are in the main those of persons who were led to study nature through a deep interest in some problem that came within their ken through everyday experiences, as Pasteur, in his investigation of phylloxera; Davy, the inventor of the safety lamp; Bell, of the telephone; and Lister, who solved the problem of infection in surgical cases.

The teacher of general science should be sympathetic with his pupils, know their interests, understand their limitations, and also their capacities, needs, and desires.

With such understanding he should be able to direct them when help is needed, and to supervise so as not to diminish the child's interest in his own undertaking.

The teacher should be free from bondage to conventional and traditional classroom methods of question and answer, and should not overemphasize the value of formal examinations. The teacher should also understand that many results in general science cannot be measured by formulæ or by definite standards. Such independence calls for courage.

Many teachers of general science must work with small and limited equipment, and be under the necessity of devising ways and means of gaining material. An advantage of such conditions is that the teacher must perforce seek her material by observation and in general reading rather than along the narrow, intensive lines of textbook and laboratory exercises. There is danger of the teacher becoming isolated and insulated from real experience; if so, work often becomes a matter of monotonous routine and drill, and there is an increasing tendency to over-emphasize petty matters of technique.

The teacher should be alert to note questions in general vogue, as Why are clouds colored? What is the sun? How does it keep hot? Such questions may indicate the lines along which pupils in general science should be directed. They also abound in suggestions for units.

The teacher should be resourceful, widely read in current scientific literature; broadly informed in the field of nature; accustomed

to observe and to seek interpretation of phenomena; frank to admit ignorance, and to recognize that many problems are unsolved. He should, however, be able to impress the pupils with his ability to go far, if necessary, in study and research upon any particular topic. Many opportunities to show this capacity will be afforded.

Teachers should guard against the temptation to use uniform material and against methods distinctly didactic; they should encourage initiative in pupils, seek to arouse real interest, and thus give instruction in general science in accordance with the aim of this subject.

Equipment for General Science.

In view of the wide range of projects and experiments from which selections may be made, an elaborate equipment is not necessary, as much may be done with material found in the school building and its surroundings. A small high school, consequently, is not at as great a disadvantage in respect to material and equipment for general science as it is in the case of subjects requiring an extensive outfit of apparatus and illustrative devices.

There should be a good sized workroom, which may be used for manual training, and possibly for the formal sciences, in which the class in general science meets. Provision should be made so that each pupil may store, when necessary, material and apparatus with which he is working. Tables of a simple type, equipped with gas and water, are required.

In large city high schools a more extensive equipment is necessary, inasmuch as it is not so easy to bring the pupil into contact with nature, and with illustrations in his surroundings.

A large amount of reading material, including magazine articles, books and newspapers, should be available. Notebooks should be furnished the pupil in which to enter the results of his reading, experimentation and observation.

The teacher in general science should build up a school reference library. Use can also be made of the town or city library. Several good textbooks are desirable out of which material can be gathered bearing upon a given topic. No single textbook, however, should be used exclusively, nor should any textbook be the basis for the kind of material or the order in which topics are considered.

The teacher of general science should have ample time in which to prepare and arrange material, and to become acquainted with the local resources in objects, processes and phenomena to be studied, observed and reported.

Optional Project Work in Chemistry

By Charles H. Stone, English High School, Boston.

While in every large class the greater number of pupils will be of average ability, there will always be a few drones, and a few students of more than ordinary calibre. One of the problems of the teacher is to devise ways to stimulate the dull pupil to more active effort, and to provide opportunity for the exceptional student to carry on additional work.

The latter problem is, of course, the easier of the two. And yet, in the teaching of chemistry, the method often followed in the laboratory for providing further opportunities for the bright student does not always seem satisfactory. It is easy enough to set the youth to work at more experiments of the same character as those he has just completed, but the charm of novelty is, to a certain degree, lacking in this case, and the youth cannot be blamed if he sometimes displays a waning interest when set to work on "more of the same thing."

In the English High School, this matter has been under consideration for some time. The method of providing bright students with additional experiments of same character as those already done was rejected for reasons given above. It was not thought advisable to turn to Qualitative Analysis, since the elements of it had already been included in the regular course. Quantitative Analysis was out of the question for two reasons; first, because the apparatus at hand was inadequate, and suitable balances and equipment could not conscientiously be asked for; and second, because even a bright high school student has not yet attained the needed skill to make work of that character profitable. But with a considerable number of bright boys, out of a registration of some one hundred forty more or less, asking for something more to do, the need of "knitting work" for them was evident. Here was an opportunity to experiment in so-called "projects" without interfering with the regular class work. It was thought that such new work should have the charm of novelty, that it should be useful and informational in character and that it should also be along the line of the student's interest. Extended project was decided upon as appearing to offer the best solution of the problem.

Accordingly, two years ago, a set of experiments on the chemistry

of Textiles was prepared. These experiments, some thirty in number, were printed off on the Neostyle, and given to any of the students who had finished the laboratory experiments required for the bi-monthly period, and who were interested in undertaking additional work. Some very creditable results were obtained, and the interest shown seemed to confirm the opinion that project work along the lines indicated was worth further development. It was evident, however, that there was need of other lines of work to better satisfy the pupil's interests.

Last year, two more sets of experiments were prepared. The first of these deals with the Chemistry of Foods, and includes: testing for starch, preparation of Fehling's solution, testing for sugars in foods, digestion of starch and sugars, fats and oils in foods, Halphen's test for cotton-seed oil, test for proteins, digestion of proteins, Babcock test for butter fat in milk, total solids in milk, preparation of casein and milk sugar, testing vinegar, and some other similar experiments. These experiments had the advantage of showing some applications of chemistry to problems of daily life, they afforded opportunity to introduce burette work in testing vinegar and making the Babcock test, and proved of much interest to the boys who undertook the work. A good deal of supplementary reading was necessitated which was valuable. Visits were made to places where food work was carried on, one visit being to the State Board of Health at the State House, where a great deal of pains was taken by the chemist to show what the state is doing in the analysis of foods, water, etc. This set of experiments appealed especially to those boys who contemplated a course at the medical or dental college, as well as to a number of others. It was noted that some boys who had not shown remarkable interest in the regular work of the laboratory were more ready to take up these experiments, when they were allowed to do so.

The second set of experiments on Industrial Chemistry was intended for boys who were interested in the applications of chemistry to industries and manufactures, or who had in contemplation a course at the Agricultural College. This set includes: preparation of emulsions for spraying trees; manufacture of ammonium sulphate from the ammoniacal liquor of the gas works, and superphosphate; preparation of lime-sulphur spray, Bordeaux mixture, Paris Green, and lead arsenate; manufacture of sodium nitrite and the preparation of a dye from it; manufacture of Solvay and caustic soda; preparation of a dye and an indicator, and the produc-

tion of pigments for use in paints. A very interesting exhibit of the products of these experiments was prepared.

A rather interesting incident in connection with the above experiments came recently to the writer's attention. Last spring one young man made a dye in the laboratory. He carried the dye home to show to his parents. Unknown to him, his mother used some of the dye to color a silk waist. The dye proved very satisfactory and the waist came out nicely colored. After it was all over, the young man learned of this interesting household experiment with his dye. It is safe to say that his experiment with that dye and the subsequent unexpected but satisfying development and demonstration of the usefulness of his product meant more to him than many another experiment performed in the regular course.

Under the textile experiments, students test cotton and wool for their reactions toward chemical reagents; they wash, scour, and bleach wool, and scour and bleach cotton yarn and cloth. The wool is taken as it comes from the back of the sheep and is made ready for the spinning process; they study the effects of acid, basic, and substantive colors on wool and on cotton, work out two-color effects on mixed goods, and carbonize wool to remove vegetable fiber; they diazotize and develop new colors on cotton, analyze dress goods, dye silk, and perform other similar experiments. The set appeals to boys who are interested in dress goods or who intend to take courses at some textile school.

The psychology involved is simple. Every one works with best effort at the thing in which he is most interested. After the regular laboratory work of the bi-monthly period is finished, the particular interest of each student is consulted, and so far as possible work along that line is given him; this interest usually falls into one of the three lines already indicated. The work appeals to him because it is different and has the charm of novelty; because it seems useful since it involves the application of the chemical facts he has already mastered to the simple every day matters of food and clothes and common industries; and lastly because the particular set he is given is along the very line in which his own interest is already working. Chemistry becomes to him now more alive than ever for he sees its usefulness in its applications to industries and to life.

It may be said that work of this character is entirely optional with the boys; no one takes it under compulsion. But also, no one

takes it who has not completed the specified amount of required experiments. For those who are interested, work of this character serves as an incentive to better economy of time and closer attention to the regular exercises in order that time may be gained for the special set they wish to do. The hold that this kind of work has is shown thus; in spite of the fact that it is entirely optional, boys appear almost every morning before school to work in the laboratory and will remain after school as often as the instructor will permit. Not always the same boys, to be sure, but the fact that any boys come, and come repeatedly, shows that they care. No boy will devote extra time in that way unless he is really interested.

It may be urged that the preparation of the experiments means a large amount of work for the teacher. Of course, it does. Material must be collected and tried out first, copy must be made and rewritten; but the manual labor of duplicating stencil copies can be turned over to some student of typewriting. Once prepared, the labor attached to the experiments is no more for the teacher than it would be if the student were to go on with such other experiments as might be assigned him from the regular manual. The increased interest and enthusiasm offsets the labor of preparation.

Introduction to the Gas Engine

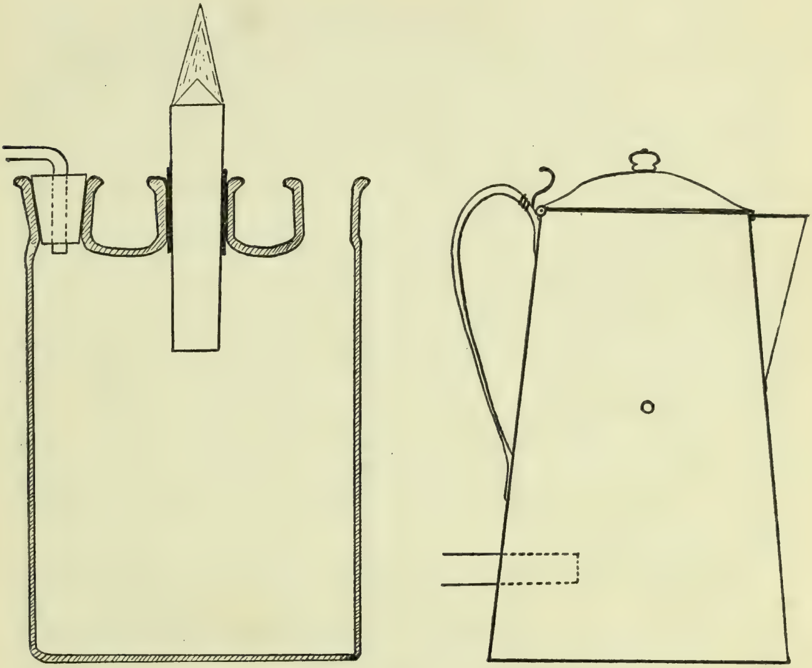
By GEORGE A. COWEN, West Roxbury High School, Boston, Mass.

The following demonstration experiments have proved very satisfactory in my classes, in holding the interest and in giving the pupil a clear understanding of the principles involved in gas mixture explosions. They are well adapted for use preliminary to gas engine study.

Fit the middle neck of a three-neck Woulff bottle with a glass tube, which extends about three inches into the bottle and four inches above the bottle. A rubber tube may be used to hold the glass tube in place. A liter bottle may be used. The right hand neck is open; the left hand neck is fitted with a stopper and glass tube for the admission of gas.

To use the bottle proceed as follows: Holding the hand over the open neck let the gas fill the bottle. When it is filled, light the gas at the top of the tube. Turn off the gas and remove the hand from the right hand opening. Air enters through this opening.

When the mixture is of the right composition a harmless explosion follows. The purpose of this part of the exercise has been to show the need of a mixture of gas and air in correct proportions to make an explosion.



The second step is designed to show the need of removing the products of explosion in order to have the action repeat itself.

To do this a coffee pot is prepared with a hole at the bottom large enough to admit a Bunsen burner. Half way up on one side a touch hole is made, so that an explosion can be caused by bringing a lighted burner to it. The first explosion occurs as soon as the mixture is in the right proportions. The cover, representing the piston of the gas engine, is thrown back by the force of the explosion. It hits a wire conveniently placed and returns to its place. The action repeats itself two or three times, but no more. When the pot, representing the cylinder of the engine is emptied of the products of combustion, an explosion will again occur.

The class is now ready to work with the real engine, a small, four cycle gas engine.

General Science Meetings

Mr. Howard C. Kelly of Springfield, Mass., gave an address on General Science, before the Hampden County Teachers' Asociation, on October 27, 1916.

General Science Club of New England held its first regular meeting on Nov. 18, 1916, in the Lecture Room of the Boston Public Library. About 75 teachers were present. Dr. Otis W. Caldwell of Chicago University gave an interesting address "An Interpretation of Our Changing Point of View." Mr. Leonard Patton, Principal of Edward Everett School, gave a practical paper on "An Experiment in Eighth Grade Science."

The Elementary Science Section of the New Jersey Science Teachers' Association held a General Science meeting on Nov. 18, 1916, in Hackensack, N. J. There were addresses by G. L. Bennett, Albert Earley, and A. C. Johnson, Jr. The discussion was opened by Miss Angie G. Albee. Miss Caroline G. Howe, chairman of the section, presided.

The Rhode Island Teachers' Science Association held a General Science meeting at Brown University, Dec. 13, 1916. An address by W. G. Whitman on "The Project Method in Practice" was followed by discussion.

The Science Division of the Oregon Teachers' Asociation gave special attention to "General Science" at its meeting in Portland, Ore., on the 28th of December. Two important papers presented were, "The Why of General Science," by Prof. L. P. Gilmore of Oregon Normal School and "The How of General Science," by Francis D. Curtis of Portland.

The Rhode Island Normal School held a General Science conference and exhibit in Providence on Jan. 13, 1917. The conference itself was a most valuable one. The exhibit was attractive and full of suggestions. There were books for texts and general use, and commercial literature of practical value. Models of stoves, derricks, engines, fireless cookers, lift pumps, fire extinguishers, etc., were shown. These are suitable for eighth and ninth grade construction projects. Community projects were represented by exhibits and demonstrations by the State Board of Health and the City Milk Inspection Department. Normal students demonstrated many applications of General Science to everyday home duties.

More than 100 Boston teachers met on Feb. 17 to discuss General Science for the Elementary and Junior High Schools of Boston. The meeting was in charge of Mr. J. Richard Lunt, of the English High School.

At the Science Section meeting of the Northeastern Minnesota Educational Association held in Duluth, Feb. 23, Mr. E. A. Stewart of Gilbert gave an address "Value and Place of General Science Course." Mr. N. J. Quickstad of Virginia, presided.

Feb. 25, at the meeting of the N. E. A. Department of Superintendence, in Kansas City, Mo., Prof. Otis W. Caldwell gave an address on "Economy and Efficiency in Science Teaching."

The second regular meeting of General Science Club of New England was held at the Boston English High School, March 10. The following men spoke upon the subjects given: Frank P. Morse, Principal Revere High School, General Science in the Junior High School. William Orr, New York, Principles of Selection and Organization of Material in General Science. A. W. Taylor, Salem High School, A Study of Weather. Geo. A. Cowen, Roxbury High School, Demonstration—Introduction to the Gas Engine. J. Richard Lunt, Boston English High School, A Project—Illuminating Gas. Howard C. Kelly, Springfield H. S. of Commerce, A Demonstration—Care of the Teeth. Chas. H. Stone, Boston English High School, Simple Experiments in Textile Dyeing. More than 100 teachers were present.

On March 29, Mr. Adrian A. Worun of Sault Ste. Marie, presented a report on "General Science in Michigan Schools" and Miss Mabel Hardy of Highland Park, presented a paper, "General Science in the Junior High School," at a meeting of the Michigan Schoolmasters' Club at Ann Arbor.

At a meeting of the Rhode Island State Science Teachers Association, held at Brown University on March 31, Mr. R. D. Tucker of the Rhode Island State Normal School gave a paper on Apparatus for General Science and Mr. R. C. Lowell, English High School, Providence, on Home Experiments in General Science.

At a meeting of the New Jersey Science Teachers' Association, at the Camden (N. J.) High School, April 14, Miss Caroline G. Howe of Newark, gave a report on the Status of General Science in New Jersey.

Book Reviews

First Course in General Science. By F. D. BARBER. Henry Holt and Company. Pp. 607.

"The Book that is different" characterizes Barber's "First Course in General Science", different from the majority of texts in General Science in at least three aspects: selection of subject matter, fewer topics are treated, but these topics are enriched with a wealth of drawings, exercises, tables, maps, illustrations, and other material.

Development of subject matter: the development is logical, thorough, and scientifically accurate. Physical laws, principles, and definitions are introduced at the point where they are necessary for a clear understanding of some of the common phenomena that the child encounters in and about the home, primarily. For example, when the author wishes to show how a chimney creates a draft, he tells the old story of Archimedes and then introduces an exercise demonstrating the law, then it is an easy step to show the analogy between a floating cork and the hot gases in the chimney.

The book is not a hodge-podge of all the physical and biological sciences. The author has avoided scrambling these sciences which later in the pupil's high school course are unscrambled.

At first glance the book may appear formidable with its 598 pages of almost solid matter, but this is a distinctive advantage in that it offers to the teacher a chance to select the chapters that might be of special interest to her students because of their environment. The book is very teachable, but in a few instances the author has carried his development beyond the comprehension of the average first year high school students, particularly his development of the efficiency of man and machines.

La Salle, Illinois. GEO. MOUNCE.

Laboratory Lessons in General Science. By HERBERT BROWNELL. The MacMillan Company. Pp. 240.

Almost without exception every author of a general science course up to this time has given the high school teachers a full year in which to become fixed in the text book method of instruction before placing a manual in their hands. Yet, they say, general science is a laboratory science. Professor Brownell's first book on this subject is "Laboratory Lessons in General Science."

Laboratory manuals have a tendency to use only the laboratory for meeting their requirements. True to the methods used by all individuals in life's laboratory, Professor Brownell, in this manual, has the pupil seek his answer in his own experiences and in books as well as in laboratory experiments. In doing this, questions call for facts the pupils have already gleaned from life. Directions help the pupil to turn to the laboratory for the assistance it can give, and specific

references enable the student to use the library readily and without an undue waste of time.

The author has made bold to take a step which no other writer of general science texts has, as yet, taken. He places the social upon the same plane with the natural sciences and stresses that phase of every topic throughout the manual.

Another characteristic, which appeals to all who regard the public schools as responsible for the moral training of pupils, is the frequent reference, in its directions, to the value of right conduct in the life of the individual student. Such a chapter as that on "General Science and Right Living" and many incidental appeals tending to lead pupils to act wisely when a moral crisis comes, are very gratifying.

The appendix contains a list of apparatus needed, a list of reference books for the library, a list of government bulletins and specific references for class assignments. Considered from many angles, it promises to be one of the successful manuals. It will, as well, be a storehouse of suggestive material for grammar grade teachers.

Peru State Normal School, Nebraska. B. CLIFFORD HENDRICKS.

Elements of General Science. By OTIS W. CALDWELL and W. L. EIKENBERRY. Ginn & Co. Pp. 308.

It is very evident that the authors of this text were serious students of the general science problem. They were aware of the fact that there was a need of and a demand for a science differing in content and method from the traditional high school science. This need has been met in this book in a very rational and scientific manner. The course presented has the "ear marks" of one tested and tried. the popular cry for "something different" did not mislead the authors into giving a spineless and highly entertainingly collection of unrelated and "near science" stories. This text has a purpose,—entirely commendable from an educational standpoint,—it is to place before the pupil some of the larger and more fundamental facts, principles and notions of the science of the common yet significant things.

The book embraces five major topics: Air, Water, Work and Energy, Earth's crust and Life upon the earth. It will be observed that a feature of the book is the comprehensive and suggestive treatment of a few rather than a brief glance at many topics.

The teacher who is very dependent on his text, will experience some difficulty in stretching this book over five periods per week for a year. It is assumed, however, that general science instruction will not be entirely confined within the covers of a single book. If one wishes to get a representative cross-section view of this text, he should examine particularly chapters I, V, VI, XII, XIII and XVI. These include those topics toward which pupils react with the greatest and the least profit.

Horace Mann School for Boys, New York. ROLAND H. WILLIAMS.

An Introduction to Science. By BERTHA M. CLARK. American Book Company. Pp. 494.

This work is virtually the author's "General Science" enlarged and expanded into a veritable cyclopedia of elementary science. True to its name it is a *real* introduction to *very much* science. Probably no other similar text contains so much information about science and its applications.

The scope of the book is well indicated by the following: heating and ventilation, foods and diet, bread making, patent medicines, soap making, paints, fertilizers, oxidation, bleaching, magnetism and electricity, sound, light, machines, gas engines, community sanitation, a short course in physiography, and some of the best things in botany and zoology.

Accordant with the spirit of present-day education, it is upon the *practical* that emphasis is laid throughout the book.

In producing a book so comprehensive and so intimately linked with contemporary life, the author has demonstrated surprising energy in exploring the vast field of science in industry, and commendable boldness in selecting what seems reasonable without regard to tradition.

Probably few teachers—particularly in larger communities—will care to present very much subject matter to their classes in elementary science that is not found in this book, and few classes will try to cover the entire book in one year.

The text is fairly well illustrated, but a more liberal use of pictures and diagrams would have improved it, and to many teachers review questions at the end of each chapter would have made the work more serviceable.

Dickinson High School, Jersey City, N. J. M. C. LEONARD.

General Science, First Course. By LEWIS ELHUFF. D. C. Heath and Co. Pp. 433.

One of the latest comers in this broad field of general science is the above title. As stated in its preface, "this book is intended to offer a scientific explanation for the many and varied experiences which pupils of high school age have had and to create a desire for further knowledge of scientific subjects." To this end, the author endeavors by his arrangement of subject matter to secure the following results: a desire on the pupil's part to grow strong in body and mind, to remain free from disease and to avoid the use of stimulants and narcotics; a development of a logical method of thinking so that pupils may have minds open to new facts and principles, thus relieving them of some of their superstitions; a desire for more knowledge and further scientific study. The author has laid out work for more than a half year, but makes helpful suggestions for omitting to fit local conditions. A textbook in general science should furnish topics and suggestions for class discussion and give the student an orderly arrangement of reference material. After a brief introduc-

tion in which the author points out many good reasons for the study of science, there follow chapters on health, chemistry of common things, cooking, carbon dioxide, breathing and ventilation, matter and energy, and the author compares nutrients, to give some idea of diet and food supply, touching finally upon the purchasing of food. Interesting cuts are inserted at frequent intervals. There is an interesting introduction to the subject of machines, following directly the work on gases.

The work on pumps is separated by four chapters from that on the barometer, for what advantage seems not clear. Considerable space is devoted to the Pittsburgh water supply, and there is in addition an excellent treatment of other systems. At this point the halfyear course ends for many schools, according to the author. He has added chapters to be used if there is time and the teacher must exercise judgment in selecting from this store, to suit his own conditions. Some of this material might properly come into the first half year displacing much of the mechanics of solids, it would seem. These later chapters include măgnetism and electricity, light, hearing, sight, an attractive account of soils, directions for care of gardens, a little elementary plant physiology, some mention of the use of plants to man, insect pests, a short discussion of animal life, and ending with a simple description of the solar system. As a whole the book is well written. The task of the teacher will be to select the material and adapt it to his own conditions. The glossary at the end is a convenience, saving trips to the dictionary. There are some excellent suggestions to teachers and each chapter is followed by a set of well worded questions. Pictures of actual plants and eminent scientists add much interest to the book. As a whole, the book is very worthy of a "place in the sun" along with the many other texts on this much discussed subject.

Central High School, Springfield, Mass. C. M. HALL.

The First Year of Science. By JOHN C. HESSLER. Benjamin Sanborn and Company. Pp. 484.

The First Year of Science is designed, in the words of the author, to "stimulate uncommon thinking about common things" in a course that shall be "fundamental to the entire field of science, and not be any one of the special sciences." Just what shall constitute such a course is a matter upon which opinions differ, as evidenced by the many varying texts published in an effort to produce a standard.

The fundamental descriptive matter in this text consists of elementary physics and chemistry, leading to matter, which in the special sciences would be classed as physiography, botany, zoology, physiology, hygiene and others. There is no abrupt division of topics under the above headings, the subjects in each chapter being presented in sequence applicable to the actual experience of the young boy or girl. There is no rigid transition from one chapter to another, however, so

that the teacher may vary the order of topics to conform to his own plan for maximum results.

Illustrations are abundant, including both diagrams and half tones. Each chapter has a summary and exercises, some of the latter being of a quantitative nature. This combination is a great help in review: the summary and some of the exercises test the anchorage of subject matter, and the particularly plentiful questions about the practical side of each topic convince the pupil that the information in this text, at least, is the kind he will want to remember because he can use it.

This text works well in class use, both as a source of readily available information and as a basis for recitations. Numbers on the topical paragraphs make the assignment of very definite lessons easy, even though one assignment may include sections from widely-separated parts of the book. The handbook for teachers has directions for carrying out simple demonstrations, answers to problems, and suggestions for rounding out much of the descriptive matter of the text itself. In the laboratory manual the great majority of the experiments call for apparatus that is usually near at hand or available at little expense. Additional diagrams here would help.

General science teachers who believe in the subject will have ideas of their own, and will do their best work putting those ideas into execution. It is still too early to look for a truly standard text that will meet the requirements of most live general science courses without modification. A text with plenty of good substantial information in science so built that it is flexible enough to give play to local ideas, and plain enough so that young boys and girls may use it effectively is the very best to be had. Hessler's First Year of Science has given very acceptable service in the classes of the writer.

New Haven High School, Conn. M. MARCUS KILEY.

First Science Book. Physics and Chemistry. By LOTHROP D. HIGGINS. Ginn & Co. Pp. 237.

General science is elementary science, but all elementary science is not general science. General science as now advocated means the science that is nearest at hand. Elementary science may lead to the comprehension of all science or it may lead to a special science. Physics and chemistry are special sciences. This book is frankly elementary physics and chemistry and not general science. Its object is to give the pupils "an introduction to scientific study" and secondly "to show the practical bearing of the various subjects upon affairs in our daily experience, such matters being introduced wherever they may serve to illustrate or explain". Many prefer to reverse this by commencing with daily life and whenever a problem needs explaining to make use of the science that is necessary at that time.

The method of the author is to begin with the simplest and progress logically to the more complex, as: elements, compounds, mixtures, common chemical processes, etc. General science begins with that

part of science which interests the pupil. It begins with lighting when it is a question in the long winter evenings; or it begins with soil when it is a matter of conserving moisture for the spring garden. The first method might be diluted from almost any text book of physics or chemistry. Both methods are scientific. Elementary science is taught for the sake of the subject; general science is taught as the subject is needed.

Although an old book (published 1905) there are teachers who prefer to have an introduction to the specific sciences and this book serves that purpose. The subject is still in an experimental stage and it is well to have teachers trying out all phases.

The book is well illustrated. At the end of each section is a list of questions which are suggestive.

Rhode Island State Normal School, Providence. W. G. VINAL.

A First Year Course in General Science. By CLARA A. PEASE. Charles E. Merrill Company. Pp. 315.

The problem of writing an elementary science book covering the field now quite generally accepted, and organizing this material in such a way that it is presented to the pupil as a series of interrelated problems, has evidently not been solved. Possibly the material of this field cannot be so organized. Our texts seem too fragmentary and the knowledge content for the present, at least, must be their principal justification.

However, other things being equal, that text which weaves its material about the fewest organizing factors has obvious advantages. From the environment of the pupil such material must be selected for such a text as will be of vital interest and at the same time be susceptible of such scientific explanation as will be within the grasp of the first year student.

First Year Science, judged by the above standard, compares very favorably with any text that has thus far come to the notice of the writer. The topics about which the material is grouped are not large and are presented in a logical way. The book, like most others on the subject, is largely an earth science text. Especially noteworthy are the first two chapters under the heading of "The Place of the Earth in the Universe." Whether or not this approach to the subject is pedagogical, when tested by the class room test, it works.

The use of scientific terminology throughout the book is commendable. It places in the child's vocabulary, and gives meaning to those scientific terms which are to be met with again and again throughout his general reading whether high school is finished or not.

The purpose of and the selection of the questions, as a whole, at the end of each chapter is most excellent. They are not only a review, but are intended primarily to test the pupils' ability to apply the knowledge gained in the chapter to concrete cases.

The style of the text is clear, concise and readable and the minimum of trouble is experienced in the pupil getting the thought. The text is not without minor errors and statements or inferences which

should not have been overlooked. Two or three illustrations will suffice. For instance, in the explanation of springs and artesian wells all layers of soil whether it be gravel, sand, clay or what not are termed rock. In the absence of any such definition of rock it is difficult to see just how the discussion will be very clear to the large number of pupils who have never seen the outcroppings of any bed rock (P. 85) The writer is not yet sure what was meant by the question "Which is more valuable, a gem cut from rock crystals or one made from Amethyst?" (P. 176) Equally confusing appear the questions 4 & 5 (P. 224) asking how we distinguish in "General" and in Particular steep slopes from a contour map.

Traverse City High School, Michigan. G. H. CURTIS.

Elementary General Science, Book I. By PERCY E. ROWELL. Published by the author. Pp. 197.

In the preface we read, "The science which is most valuable to the child is that which explains the phenomena of the environment—the science of common things—the science of everyday life. No one branch of science can do this. . . . A blending of all branches of science, as a means for the best teaching of it in the grades, is inevitable."

There is a dearth of science books for the elementary schools and many teachers will find this little book of much value in their classes. It has numerous illustrations. R. M.

Introduction to General Science with Experiments. By PERCY E. ROWELL. The Macmillan Company. Pp. 295.

This was published in 1913 and no later edition has yet appeared. No space is given to drawings or pictures. The work is certainly true to its name, it is *general.* No particular branch of science is emphasized. Chemistry, Physics, Geography and Botany are interwoven. The plan of the book is splendid. A paragraph or two is given on a subject, then a number of definite references are cited where the pupil may find a more extended discussion. An experiment usually follows.

In the front part of the book a good list of references is found with directions for use. The experiments are interesting and stimulating and well within the grasp of a first year high school student. They can easily be performed in a forty-five minute period and no elaborate apparatus is necessary.

I found this book of great service in my first year classes. However, I would not recommend it to an inexperienced teacher as a text, for to be of value it must be used together with the references.

Boston Trade School. THOMAS D. GINN.

First Year Science. By WILLIAM H. SNYDER. Allyn and Bacon. Pp. 470.

This text is an attempt to unify the elements of some ten special

sciences in a course which deals with the earth and the sun in their relation to man. The text really is physiography with rather more than ordinary emphasis upon related science topics. It is in simple language and is well illustrated. Has summaries and questions at the ends of chapters. There are 133 experiments in fine print included within the text. It is a little questionable to state as the author does in the preface, that "The book is complete in itself; no reference library, no manual, is needed." R. E. N.

An Introduction to the History of Science. By WALTER LIBBY. Houghton, Mifflin Company. Pp. 288. $1.50.

Here is a history of science which will fascinate high school students. The scientists and the stories of their work, here told, are so closely interwoven with the subject matter of high school science that they will serve to vitalize the entire science curriculum. The practical bearing of science from remote early times to the present is a feature of the book. The frontispiece in this number of the Quarterly is one of the plates which illustrate this book. Libby's History of Science will give student or teacher an added appreciation of science of today through the background of the science of the past. W. G. W.

Problems of Secondary Education. By DAVID SNEDDEN. Houghton, Mifflin Company. Pp. 333.

Three chapters in this book are in the form of letters written respectively to teachers of physics and chemistry, to teachers of biology and to general science teachers. Not only are the present day defects in our science teaching clearly pointed out, but many suggestions are offered for securing a new, successful and useful program of science in the high school. No progressive science teacher will fail to read these chapters and to meditate thereon. W. G. W.

LABORATORY MANUALS IN GENERAL SCIENCE.

BARBER. No laboratory manual is published, but there are 103 exercises scattered through the text in appropriate places. These are in fine print to set them off from regular text material.

BROWNELL. *Laboratory Lessons in General Science.* Reviewed above.

CALDWELL, EIKENBERRY and PIEPER. *A Laboratory Manual for Work in General Science.* 94 exercises, 134 pages. The exercises are printed on large sheets with blank space for the pupil's rcords. It is supplied either as a bound volume or as loose sheets.

CLARK. *Laboratory Manual in General Science.* 92 experiments, 96 pages. This was written to accompany Dr. Clark's first text, General Science.

CLARK. *Laboratory Manual for Introduction to Science.* 100 experiments. 203 pages. Large sheets, in loose-leaf form. Blank spaces are left beside the printed directions for the pupil's notes.

ELHUFF. *Laboratory Manual for General Science.* 112 exercises, 90 pages. The author suggests that many of these exercises be made demonstrations by students or instructor. Some exercises are recommended for home work.

HESSLER. *Laboratory Exercises for the First Year of Science.* 107 exercises. 118 pages. This is to accompany the author's text. Each exercise is prefaced by a list of apparatus and materials needed.

PEASE. Laboratory Manual. 31 exercises. 41 pages. Each exercise refers to the definite sections of the text book, to which it is related. Bound with the text or separate.

SUMMER COURSES IN GENERAL SCIENCE.

UNIVERSITY OF CALIFORNIA. *Theory and Practice of Instruction in Introductory or General Science.* The course is given by Percy E. Rowell, A-to-Z-ed School, Berkeley, Cal.

COLUMBIA UNIVERSITY, TEACHERS COLLEGE. *The Teaching of General Science in the Elementary and Junior High Schools.* Two courses for class work and a laboratory course. The courses are given by R. H. Williams and A. I. Lockhart of the Horace Mann School, New York.

COLUMBIA UNIVERSITY, TEACHERS COLLEGE. *Organization of High School Science.* In this course more attention will be given to general science than to any other one science subject. Given by Otis W. Caldwell, of Teachers College.

HYANNIS (MASS.) STATE NORMAL SCHOOL. A general science course has been given for the last four years, but is not offered this summer.

ILLINOIS STATE NORMAL UNIVERSITY. *A course in General Science for High School Teachers.* This course has been offered for the last three years under the direction of Fred D. Barber. This summer the course is given by W. L. Goble, Principal of the Elgin High School.

IOWA STATE COLLEGE. *General Science for High Schools.* Fred D. Barber will give a course similar to the one he has given in previous summers at Ill. Normal University.

KIRKSVILLE, MISSOURI, STATE NORMAL SCHOOL. A course in general science will probably be given in the summer session by W. J. Bray of the Kirksville Normal School.

UNIVERSITY OF NEBRASKA. *Teacher's Course in General Science.* Suited to high school use. Classroom and laboratory practice. The course is given by Herbert Brownell, of the University of Nebraska.

PERU, NEBRASKA, STATE NORMAL SCHOOL. *Course in General Science for High School Teachers.* Classroom and laboratory. Course given by B. C. Hendricks, of the Peru Normal School.

UNIVERSITY OF NORTH CAROLINA. *General Science.* Course is given by P. H. Daggett of the University.

UNIVERSITY OF PITTSBURGH. *General Science in the Junior High School.* Course I. G. S. in Seventh and Eighth Grades. Course II. G. S. in Ninth Grade or First Year of High School. The courses are given by W. G. Whitman of the State Normal School, Salem, Mass.

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The Aims and Methods of Science Teaching

By John F. Woodhull, Teachers College, Columbia University.

The aims and methods of science are best portrayed in the lives and labors of those masters of science who have lived since the time of Galileo, notably Pasteur and Faraday. These aims and methods are now so generally approved and applied by the teachers of all subjects that the "scientific" method no longer distinguishes the science work from other work in the schools. Science teaching, if it follows the examples of Pasteur, Faraday, etc., may not justly be differentiated from other subjects as materialistic or lacking in cultural or humanitarian elements.

The purpose of science teaching in all grades of schools is not chiefly to impart knowledge of subject matter but to train persons in the method of the masters, which is invariably the *project method.* This is the method used by intelligent men in achieving their ends, in school or out.

A project in characterized in the words of Prof. Mann as follows: "(1) A desire to understand the meaning and use of some fact, phenomenon, or experience. This leads to questions and problems. (2) A conviction that it is worth while and possible to secure an understanding of the thing in question. This causes one to work with an impelling interest. (3) The gathering from experience, books and experiments of the needed information, and the application of this information to answer the question in hand."

A *project,* or *problem,* differs from and is superior to a *topic* in that (1) a project originates in some question, and not in such a logical sequence of ideas as may be found in codified subject matter. In teaching from the so-called "logical" texts one wrongly attempts to induce pupils to accept topics as their own projects. Logical organization of such material as functions in life will be the final result of a protracted study of projects. (2) The project involves the active and motivated participation of the pupil in carrying it out. It does not, therefore, like the topic lend itself to didactic,

formal treatment in which the teacher does all the thinking and the pupil passively absorbs. (3) Projects furnish a basis for the selection of facts according to value or significance, topics furnish no such basis for selection. (4) The project seldom ends in a complete, final or absolutely finished conclusion. It is, therefore, far less likely than is the topic to leave the pupil with the idea that he has heard the last word on the subject. It leaves him open-minded. The project, or problem method of teaching when well done leaves the pupil with a well-organized mass of useful information plus a method of work which will lead him to continue to acquire more. This entire discussion arises from the fact that the logical, topical method has failed to do just this.

Children and adults alike are endowed by nature with the elements of the scientific spirit. The purpose of science teaching is accomplished most successfully when the science classes merely furnish and shape an environment in which the scientific spirit may grow. Under the direction of a teacher who comprehends the workings of the mind, the project method duplicates the methods of active life and thus prepares the pupil for independent thinking.

The present need of the schools is for a large collection of sample projects, or problems, which may be used in showing teachers in a given community how to devise and utilize projects adapted to different grade of pupils in their own environment. The curriculum is the sum of such projects. It must always remain in a state of flux.

A fuller discussion of the project method may be found in the following books and articles:

Science Teaching By Projects
School Science, Vol. 15, pp. 225-232; March, 1915.
General Science and Projects in Science
Teachers College Record, N. Y., Vol. 17, pp. 1-21; Jan., 1916.
General Science and Projects; David Snedden
School and Society, Vol. I, pp. 436-441; March 27, 1915.
Project Teaching; William H. Kilpatrick
General Science Quarterly, Vol. I, pp. 67-72; Jan. 1917.
How We Think—By John Dewey.
Democracy and Education—By John Dewey.
How to Teach—By Strayer and Norsworthy.
A Brief Course in the Teaching Process—By George D. Strayer.
See also Boy Scout Handbook, Doubleday Page & Co., and various manuals on Agricultural Education.

The Aims of Science Teaching and Changing Enrollment

ELLIOT R. DOWNING, School of Education, University of Chicago.

A comparison of the data given in Inglis's "The Rise of the High School in Massachusetts" with those in the 1916 Reports of the United States Commissioner of Education seems to show that there has been a marked decline in the enrollment of science in Massachusetts in the last fifty or sixty years. The figures which Inglis was able to obtain were rather meagre, though they are from such representative towns as North Hampton, Haverhill, Worcester, Newburyport, Lowell, and Springfield. Those for the last two cities are the more complete, and I give in the following table a comparative statement of the number of pupils taking certain subjects in Lowell, Springfield, and Massachusetts, expressed in terms of the percentage of the total high school enrollment. The data for Massachusetts are taken from the last Report of the United States Commissioned of Education.

Subjects	Lowell Av. per cent. 1849-51	Springfield Av. per cent. 1855-61	Massachusetts Av. per cent. 1914-15
Algebra	22.	34.8	33.99
Geometry	5.	27.5	19.71
Latin	37.	41.9	26.69
Greek	2.5	3.6	1.
French	31.	19.5	39.3
Botany	2.5	11.6	5.8
Chemistry	12.5	13.5	8.78
Natural Philosophy	26.5	16.8	Physics 19.71
Physiology	21.5	23.3	5.55
Physical Geography		18.	4.15
Zoology		17.3	1.32
Household Science		15.7	Dom. Economy 6.56
Bookkeeping	35.5	13.9	8.85

The total percent in science in the Springfield high school in the years given, including Household Science is 129.9 per cent.; in

Lowell, 77.5; in Massachusetts 1914-15, 50.18. There are included in the above tabulation some other subjects in addition to science for comparison.

The total science enrollment in the country, expressed in terms of percentage of total enrollment has decreased in the past five years 5.83 per cent. (1916 Report of the U. S. Commissioner of Education, Vol. II, page 489). Chemistry is the only science which shows an increase; Physics has nearly held its own; Physical Geography and Physiology have had a considerable decline; the proportion in Botany has decreased 44 per cent.; and in Zoology more than 50 per cent. It is true that Agriculture and Biology have gained in some sections of the country very materially, but these gains do not compensate for the losses in the old-line science subjects. It is also true that there has been a more marked decline in certain other groups of subjects, than in science, such for instance, as in the Classics, 11.04 per cent., and Mathematics, 10.37 per cent. of the total enrollment.

It would seem, to use the words of Snedden "that educators generally who look broadly into the field of secondary education must experience a sense of disappointment as to results now achieved through science teaching."* The figures, apparently, are statistical evidence of such disappointment. Snedden believes that the "fundamental difficulty, here as elsewhere in the field of secondary education, is that we have not yet clearly defined the purpose to be kept in view in our teaching."

Certain it is, that there is no unanimity of opinion as to what science is trying to accomplish either in the grades or in the high school. As a result the course in science lacks coherence; there is no dependent continuity. While much of the science teaching is good in a single subject, it is not coordinated with other sciences of the high school, much less with any work that has preceded in the grades.

As a contribution to the survey of the whole field of science work in the public schools, I submit the accompanying tabulation of purposes. Until we come to some general accepted outline of aims, it is relatively useless to undertake a discussion of methods, for the ends we are trying to reach determine largely the methods we shall use to attain them.

* Snedden, David, Problems of Secondary Education, p. 232.

The purpose of science instruction may be tabulated as follows:— The length of the block indicates roughly the proportion of pupils interested in the particular aim; the height, the relative importance of it. The statement of an aim under a definite portion of the school indicates not that it is absolutely confined to such limits but that it is here to be stressed as the most suitable thing for the particular stage of the pupils development.

The Grades	Junior High School	Senior High School	
	The intelli with a know sciences on	gent choice of a vocation and of an avocation, ledge of the fundamental principles of the which these are based.	**Knowledge of Organized Science**
The establishment of thinking (*i. e.* thinking to cor- on the basis of observed carrying the conclusions The stages in scientific think- of the scientific attitude as follows:— *A.* Rendering concepts exact at essential likenesses: the (*a*) By a careful accumu-	(1) a *habit* of scientific rect proximate conclusions facts.) (2) a *habit* of over into action. ing (in the development of mind) may be outlined by analyzing things to get "What Stage." The achievement of a as a conscious ideal, solving life's problems pendent opinions (3) Realize that as an ed- thinking is incomplete corporated in the life *B.* The problem-seeing, problem-solving type of Problems are of the concrete type first. How do you do it? How does it work? The "How Stage" The problem is solved. lation of facts. (*b*) By devising hypothesis to explain them. (*c*) Testing these out *C.* The application of an already particular experience.	scientific *attitude of mind* to serve as (1) a means of (2) as a stimulus to inde- as a basis of wise action. ucational process, scientific until the conclusions are in- of the pupil. reaction to environment. Later they are abstract: the "Why Stage" by experiment to find the true. established law to a	**Habitiual Scientific Attitude of Mind**
Even before the pupil comes to be problems to shape his actions to meet set up an electric bell, cultivate a order to give practical skills and to	sufficiently aware of some of the economic scientific them it is wise to train him to repair the pump, garden, raise fruit, care for chickens, etc., in stimulate interest in problems that are involved.		**Practical Skills**
An intellectual and Some appreciation of A grasp	aesthetic appreciation of the com the achievements of science and of the devoted of the moral import of the orderliness obligation to adjust himself	monplace environment. labors of scientists. of nature and of the pupils to her laws.	**Appreciation**
Acquisition of the habit of healthful personal and community living.	and a knowledge of the facts and principles that underlie such hab	its.	**Health**

Until the allied sciences come to some general agreement on the objectives to be reached, there can be no concerted action, no plan of campaign that will assure an advance all along the line in science. I conceive that the science teacher is not teaching science for its own sake, at least not until fairly late in the course of study. To test out results only in the terms of the information acquired, is to ignore the accomplishment of the more important ends. Habits and attitudes of mind, as tools of inquiry in settling the problems of individual living and of a democratic society, appreciation and ideals, are the real things to be achieved in public school science, and the organized knowledge of the sciences and the method of science are means to an end.

Aux Morte

enfants de la patrie, qui, tombé sur le champ d'honneur, ont donné à la France une gloire sans pareille.

Vive la France! The bugles blew
To summon men from town and field,
'Neath day's warm sun and night's cold dew
To fight and die, but not to yield,
Staking their lives on War's grim chance!
Vive la France!

Vive la France! They marched away
To stop the huge onrushing wave;
On smoking plain, by forest gray,
They saved their land and found—a grave.
No further shall the Hun advance!
Vive la France!

For them no more the cannonade,
The champaign scorched with liquid fire,
The camp, the trench, the wild parade
Of charging hosts through mirk and mire.
Sleeping, they dream in Death's cold trance,
Vive la France!

The night breeze wanders o'er the plain
Defiled no more by cruel foe;
The ghostly starlight seeks in vain
The valiant dust that sleeps below;
The winds croon where the moonbeams glance,
Vive la France!

But if once more the foe should come
To scourge the land with fire and gore,
To blast of bugle, roll of drum,
These sleeping dead would rise once more
In spirit, seizing sword and lance,
Vive la France!

Vive la France! Strew fadeless bays,
Sons of brave sires, above their dust,
And sing again their Marseillaise
With larger hope and firmer trust!
Toujours la Liberté avance!
Vive la France!

C. H. STONE

General Science in the Junior High School at Rochester, N. Y.

Harry A. Carpenter, West High School.

Part II. Courses of Study.

The year that has passed since the publication of Part I of this article has been fruitful. The experiences gained have added much in the way of new material and new methods. The ideals, which the science teachers of the Junior High Schools hold, are much the same as they were a year ago but with still greater emphasis placed upon the need of training pupils how to study and to think. We still believe that general science should give the pupils experiences and training which they may immediately apply. We are more than ever convinced of the value of general science for seventh and eighth as well as ninth year pupils. It would be possible to give instance upon instance of the interest manifested by boys and girls in all sorts of science topics that are really related to the home, the school, the street and the community. They are genuinely interested in the every day things. Their interest does not depend upon science of a spectacular or unusual nature.

It is too early, perhaps, at this time to judge accurately as to the value of this general science in its relation to later high school science but it is not too much to say that the majority of the pupils have acquired an alertness, a power of observation and a pleasure in science that will play a significant part in their later work. That they have received a large amount of useful information and have been awakened to the reality and the beauty of nature is certain. Many of them have evidenced real acuteness of thought and have attained unexpected ability in scientific study and methods. The past year's study of the problem, together with former experiences in general science, has confirmed our conviction that general science should in no sense be considered a "try-out" course for boys and girls to enable them to select for later intensive study any of the special sciences. It is true that some of our pupils have shown an aptness for some of the special sciences which we shall endeavor to foster as they go on into high school, but we believe that general

science should have for its major aims the study of the immediate surroundings of the child, the betterment of his health and his mind.

As a result of two years work it seems best to place general science in the seventh, eighth and ninth years, whereas in the beginning the science work of the eighth year was limited to hygiene, organized as a part of the physical training. Likewise a ninety minute period for science work for the seventh grade pupils has proved excessive in length. A resourceful teacher can hold the attention and interest of the children this length of time for a day or a few days in succession but no teacher can be expected to obtain the best results that science teaching offers the opportunity for, if she must exert herself continuously day after day with 90 minutes for each class. Both teacher and pupils tire. Neither does it seem possible to devise any sort of laboratory or busy work which of itself holds the interest and eagerness of a seventh year child for a long period. Hence at present, our time schedule is as follows: Two forty-five minute periods per week throughout the entire year for pupils in the seventh and eighth grades and three ninety minute periods per week throughout the entire year for ninth year pupils.

Experience has taught something along the line of class trips. We have concluded that with a large class of boys and girls short trips of 15 to 30 minutes, in the vicinity of the school are more productive than the extended trips. Every class takes a number of these outdoor excursions, each excursion having a very definite and at the same time limited object in view. As the observations to be made on any one trip increase in complexity so is the clearness of the child's vision dimmed and the value of the trip lessened, particularly is this true for the seventh and eighth year pupils. Most of our more extended trips are organized on the basis of delegates chosen by the class groups to represent them. These delegates are told before hand what particular thing they are to be responsible for on the excursion as a whole. For example, if there are five ninth grade classes, and four delegates are selected to represent each class in a visit to a modern creamery, the creamery operations would be divided into four processes or groups of processes, and one delegate from each class would be made responsible to report in detail about his particular process to his class. A group of twenty boys and girls is about all one teacher can see to adequately on a trip to a commercial institution. This plan has the disadvantage, to be sure, that some of the pupils do not see some of the commercial

processes. This is made up for in part by allowing members, other than the elected delegates, to attend the trips by special permission. This scheme has the very marked advantage of eliminating certain pupils who are sure to be uninterested and mischievous and one or two such persons on an excursion will prove a considerable handicap. It should be understood that wherever and whenever it is practicable the entire membership of the classes are taken on excursions, especially is this true of outdoor excursions and to some commercial establishments.

The observation bulletin referred to in the previous article has grown in importance. To send a pupil out into the byways to make a particular observation and to report thereon, insisting upon accuracy both of the observation and of the report has proven of genuine value. This observational work admits of an unusual amount of individuality and often gives the teacher an insight into the pupils interest quicker than any other part of the work.

The added experience has deepened our conviction that the so-called individual laboratory experiments are to a large extent unsuited to seventh and eighth grade pupils and are only slightly more suitable to the ninth year pupils. The average seventh and eighth grade pupil will make play of the individual experiment and fail to reap the benefit hoped for, whereas in the "group experiment" each child is made to feel his responsibility toward the others of his group and toward the rest of the class, to whom he must report, and is likely to do his part well. Demonstrations by the teacher have been reduced to a minimum. Demonstration work of all sort is done by the better, more skilful pupils. This activity which is allotted only to the most careful pupils serves as a stimulus to many in the class to excel their neighbor.

We have done away entirely with the set laboratory period. Every science teacher has undoubtedly felt the impossibility of keeping class work and laboratory work going hand in hand under the plan of special laboratory days. In the Junior High School all of our work may be considered laboratory work inasmuch as the pupils must record in note books data on the problem at hand collected from so-called laboratory work itself. To this is added data collected at home or on the street and data obtained from the study of books pertaining to the subject. This means that the text-book study of the pupil is devoted at once to a purpose. Instead of studying to learn or memorize what a certain author has thought

wise to tell about a topic, our boys and girls study a text book to get information which will enable them to solve a problem. As far as possible formality in the writing of notebook reports is reduced to a minimum since formality necessarily hampers individuality. For the convenience of the teacher in inspecting the note books, and at the same time to teach the pupil the value of note book methods, some small amount of formality seems necessary. The pupil is made to feel the value of indicating in his note book, information which he obtains second hand from a fellow observer or from a text book or from his teacher. He is asked to indentify or distinguish plainly this sort of material from the data which be obtains as an individual and which to him has all the attributes of real discovery. In this way and by requiring adherence to accuracy we endeavor to keep the value of truth always in the foreground.

At the end of this article will be found a brief but suggestive outline of the topics used as a guide in our science work in the Junior High School. It must be kept in mind that these topics are not considered final. Any outline of topics for a course in any science should be considered by the reader from the standpoint of the pupils whom it is to serve. Any outline, at best, is a poor substitute for the details as worked out in the class itself. The outline of topics which follows is intended to give the reader an idea of the viewpoint from which we try to present the subject matter as well as topics covered. The subject matter itself must, in all cases be adapted to the mental development of the child.

It will be noticed that the work is not divided in any sense into short courses of the various special sciences. To find the physics or the chemistry or the biology one must follow the workings of the development of the topic. For example, there is a considerable amount of hygiene given under the cover of every topic in the outline. Some topics of the physical sciences are worked out in the development of the study of foods and the study of ventilation and illumination of houses, etc. Some teachers will at once wonder at the absence of topics on electricity. The writer and his co-workers feel that electricity such as can be taught in the ninth year partakes almost entirely of the nature of play and this same playwork can as well be done by sixth grade pupils. It is our conviction that topics of electricity are more suitable for later high school study.

This same outline of topics is used by the Household Arts pupils for a portion of their science work and also by the pupils of the

Industrial Arts Courses. Too often teachers lose sight of the fact that the boy who is being given training for shop work to be taken up as soon as he leaves elementary school, needs perhaps more than all other students to have his senses made alert to the beauties of nature, to have his eyes opened to the things about him which otherwise he is so likely to miss when he gets into the shop. The more likely it is that boys or girls in their life work may be tied up indoors at the bench or the machine or the desk, so in the same proportion is it incumbent upon us as teachers to give them the inspiration needed that will draw them out of the shop, out of the store and out of the house into the open. The particular emphasis of a topic, as taught to boys and girls who plan later high school work, may not be at all the proper emphasis for the boy who plans to spend his energies in the shop or the manufacturing plant. Therefore we vary the emphasis and the application depending upon whether the boy or girl is in the Household Arts Course, the Industrial Arts Course or the Academic and Commercial Courses leading into the high school. All of these boys and girls irrespective of their later life interest and vocation should be given the same opportunity for training that makes for better health and happiness and appreciation of nature throughout their life. They should be given the same opportunity for mental and moral education, and that science lends itself particularly to these purposes is evident.

Now, as at no other time in educational history, is it necessary that we teach conservation—of fuels, of foods, of health and of time. We must eliminate the waste from our work so that we may do the most for our pupils in the shortest possible time. Now if ever must the science teacher train the child for democracy, and set up democratic ideals by example and precept. General science opens wide the doors of opportunity in this time of need, and worthy of the name is that teacher who enters, hand in hand with his pupils.

In the general science courses a fair balance between biological sciences on the one hand and physical and geographical science on the other is maintained although the work is not separated into the special sciences. The pupil's work is definitely mapped out for him and concentrated, productive effort is required at all times. The attempt is made:

1. To develop powers of observation and awareness of surroundings, and so add to the pupil's experiences.
2. To help the pupil gain simple accurate concepts.

3. To help the pupils to an understanding of the common phenomena of their immediate environment.
4. To train the pupils to be able to apply experiences and concepts acquired to the solution of new problems.
5. To train the pupils in the science method of procedure and study.
6. To establish an habitual scientific attitude.

The methods used include supervised study, laboratory work, demonstration, recitation and excursion, (individual and group).

The topics for study are arranged in groups and the information and training obtained by study of any group is made to play a definite part in the study of succeeding groups. The arrangement of groups is somewhat determined by seasonal changes. The arrangement of topics within a group is either psychological or logical as the particular case demands.

Directed outdoor and home observations are carried on by all pupils. Oral or written reports are made out on all observations and inferences drawn therefrom.

The science work is made to serve as a vehicle for moral instruction whereever it is suitable.

Throughout all courses the home, street, school and city environment as contributing to the physical, mental and moral development of the pupil is made the keynote of the science study.

Individual pupils are encouraged to continue, as special problems, the particular line of science that seems to interest them most or for which they seem best suited, with the hope of keeping their particular interest alive until it can bear fruit.

Pupils are urged to continue their special interests or hobbies through the medium of Science Club Organizations.

General science is required of 7th and 8th grade pupils. The time for this work is 2 periods (45 minutes each) per week for the school year.

7 A and 8th grade Household Arts and Industrial Arts pupils are given work especially adapted to their special needs.

General science in these grades is correlated with the work in history, civics and geography.

General science is required in the 9th grade. The time for this work is 3 periods (90 minutes each) per week for the year.

In the Academic and Commercial courses biological science as interpreting the health and hygienic needs and habits of adoles-

cence, civic sanitation and the pupil's environment forms the keynote. Much use is made of the helpful parts of the special sciences particularly as applied to milk and water supplies, heating and ventilating, illumination, household mechanics, foods and nutrition, growth and disease of plants, etc. The course is not at all divided by lines that mark the usual boundaries of those special sciences.

The science for the Household Arts and the Industrial Arts pupils is planned so as to emphasize their special needs.

The Household Arts pupils require considerable work in food chemistry while the Industrial Arts pupils need more intensive work in physical science as applied to machines and shop practice.

Outline of General Science Courses.

7 B and 7 A Grades.

Fall Term:

Rocks:

1. Rocks as building stones.
   Limestones, sandstones, marble, granite.
2. Rocks and minerals.
3. Rocks as soil producers.

Soil:

1. Formation of soil.
2. Soil in relation to plant life.

Rivers:

1. Rivers as soil makers.
2. Rivers as soil distributors.
3. Rivers and flood control.
4. Rivers as a means of transportation.
5. Rivers as a source of power for industries.
6. Rivers for beauty and health.

Observational work:

1. Bird life, (one or two special birds).
2. Cocoons.
3. Spiders.
4. One familiar tree (maple, elm, etc.)
5. Seed dispersal.
6. Frequent outdoor temperature readings.
7. Observation of wind direction.
8. The "North Star", "The Big Dipper."

9. The equinox.
10. Conservation as applied to: *a.* Soil fertility; *b.* water power; *c.* forests; *d.* birds.

Spring Term:

Air:

1. What air does. Combustion. Oxidation.
2. What is good air?
3. Good air and health.
4. Hygiene of breathing.
5. Good air and proper breathing a means of disease control.

Fire:

1. Feared and worshiped by man.
2. Uses of fire.
3. Loss by fire.
4. Fire prevention measures.

Observational Work:

Special Days.

1. Arbor day.
2. Bird day.
3. Clean up week.

General:

Bird study.
Temperature readings.
Wind direction.
Planets—"Morning and Evening Stars".
Continue tree observations,
Branching, budding, flowers, leaves.
Home garden planning.
School garden planning.
Conservation as applied to: *a.* Health; *b.* Fuels; *c.* Building material.

8 B and 8 A Grades.

Fall Term.

Personal Hygiene:

1. Kinds of soap and how they are made.
2. How soap cleanses.
3. Use of soap in the laundry,
   Removal of stains.

4. Substitutes for soap.
5. Soap and a clean skin—a clean skin and the health.
6. Tooth paste and powders—hygiene of the teeth and mouth.

Community Sanitation:

1. Garbage disposal.
    a. Recepticles for garbage. Kind. Care.
    b. Prevention of flies and odors.
    c. Collection of garbage. Methods. Efficiency.
    d. Method of sewer disposal. Saving the fats.
    e. Rochester plan.
2. Sewage disposal.
    a. Sanitary plumbing. Care. Use.
    b. City sewers.
    c. Rochester plan.
    d. Other plans.

The Heavens:

1. The Earth and her moon.
    a. Location of places on the earth.
       Latitude and longitude.
    b. The motions of the earth and their effects.
    c. Time on the earth.
2. Our sun and his family of planets.
3. The stars and constellations.
4. Archimedes, Galileo, Newton.

Observational Work:

1. The winter birds and their entertainment.
2. Frosts and their effect.
3. The study of a special tree—a shrub.
4. Wind direction and velocity.
5. Air temperature—observations.
6. Planets and constellations.
7. Seeds and seed dispersal.
8. Grasshoppers.
9. Conservation as applied to: *a*. Foods; *b*. Crops—seeds; *c*. Birds.

8 B and 8 A Grades.

Spring Term:

The Weather:

1. Weather, likes and dislikes.
2. Sayings about the weather.

3. Weather factors.
    a. Temperature—Thermometer and its use.
    b. Winds—Direction, velocity, cause.
    c. Air pressure—Relation to storms; How to measure.
    d. Humidity and Health.
    e. Precipitation—Clouds, rain, snow, dew, frost.
4. Climate in relation to crops, industries, health.
5. Weather Predictions.
    a. Pupil's prediction based upon personal observation of weather factors.
    b. U. S. Weather Bureau predictions—value.

Water:

1. Its occurrence in nature.
2. Properties, impurities and use of water.
3. The local water supply.
    a. The home Water Works.—Faucets, Water pipes, Meters.
    b. The city reservoir and distributing conduits.
    c. The lake sources—Their altitude and results; Sanitary control of shores and drainage area.
    d. Local needs and methods for purification—Home treatment—boiling.
    4. Purification methods of other cities.
    5. Vacation dangers in drinking water.
    6. Chemically pure water—distillation.
        Application of process of distillation.—Gasoline, Benzine, Kerosene, Lubricating oils, Alcohols.

Gardening:

1. Preparation of soil.
2. Planting.
3. Care of plants.

Observation Work:

1. Daily weather observations.
2. Bird life.
3. Flies, mosquitoes.
4. Fire risks.
5. Tree study—branching, budding, etc.
6. Conservation as applied to: *a.* Drinking water supply; *b.* Fuels—gasoline, kerosene, alcohol; *c.* Health.

Fall Term:

Animal Helpers:

1. Birds vs. insects.
2. Toads *vs.* insects.
3. The economic importance of the earth worm.
4. Fish.
5. The cow and the horse.

Efficient Man:

A. Food Studies.
   1. Preparation of food.
   2. Foods and diet.—How the body utilizes foods to produce greatest efficiency of body functions, digestion, circulation, etc.
   3. Pure foods and drugs.
   4. Grocery sanitation.
   5. Kitchen sanitation.—Saving food from the garbage pail.
   6. Nutrition aids.
   7. Nutrition handicaps.

B. Good air studies.
   1. What is good air?
   2. How to obtain good air.—Ventilating and heating: *a.* Home; *b.* School; *c.* Shop; *d.* Store.
   3. How the body uses the air.
      a. The lungs.—Function, Care.
      b. The skin.—Cleanliness vs. function.
      c. Posture and exercise.
      d. Respiration and disease.

C. Studies of body wastes.

D. The nerve control.
   1. Automatic. 2. Voluntary.

E. Illumination and color.
   1. Home, school and shop lighting.
   2. Wall paper and colors.
   3. Good eyesight an asset.
   4. Poor eyesight a handicap—its correction.
   5. Prevention of blindness.

F. Personal Hygiene.
   1. Hair. 2. Nails. 3. Skin. 4. Clothing. 5. Shoes, etc.

Observational Work:

1. Birds, insects, toads.
2. Seeds and seed dispersal.

3. Fall planning for gardens.
4. Weeds.
5. Tree study.
6. Amateur weather forecast contests.
7. Conservation as applied to: *a.* Insects; *b.* Birds; *c.* Animals; *d.* Foods; *e.* Health.

Spring Term:

Germs:

1. The smallest plant and animals.
   A. How they hinder man.
   B. How they help man.
2. Plant diseases. Animal diseases.
3. Germs, yeasts and molds as related to the preservation of fruits and vegetables.
4. Prevention and control of disease.
   Immunization.
   Vaccination.—Smallpox, Diptheria, Whooping Cough, Typhoid fever.
   Eradication.—Antiseptics, Disinfectants, Pasteurization, Sterilization.
   Elimination of carriers.
   Personal hygiene.
   Public hygiene and sanitation.

Milk:

1. Milk, its food value.
2. Clean vs. dirty milk.
3. Pasteurized vs. raw milk.
4. Problems of the production, transfer and distribution of clean, wholesome milk.
5. Utilization of unused milk.
6. Proper care of milk in the home.
7. Danger of disease distribution in milk and its control.
8. Civic hygiene as related to milk.

Plants:

1. Our dependence upon plants.
2. Proper conditions for the growth of plants.
3. Plants in relation to food, shelter and clothing.
4. Care of plants—cultivation, watering, spraying, propagation.
5. Planning a garden.
6. Weeds.—Their control.

General Science in Michigan

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The subject of general science has been discussed throughout the country for the past five or six years. Its aims, advantages, place in the curriculum, content and method have been the subject of articles in educational magazines; committee reports have been published on it and science conferences have considered it from all angles. Surveys have been made of general science in other states; this report is made so that the status of general science in Michigan may be known.

The data which is the basis of this report was received from answers to a questionnaire which was sent to the high school science instructors in the schools on the 1916 accredited list of the University of Michigan. Accredited schools were chosen because they, it is assumed, are representative of Michigan schools; and furthermore, they are the schools that are interested in university recognition for general science. As the questionnaires were answered in the fall of 1916, this report deals with the conditions of general science for the first semester of the school year 1916-17. One hundred and seventy-two of the two hundred and eighty-three schools on the list replied.

When answering the question, "Is a course in elementary or general science offered?" instructors were asked to distinguish between elementary and general science according to the distinction made by Prof. E. D. Huntington of the Western Normal of Michigan as given in his Discussion of the Report on the Elementary Science Situation in Michigan, printed in the Journal of the Michigan Schoolmasters' Club, 1916.

"The essential difference between elementary and general science is that the former would present the elements of certain specialized sciences to the child from the standpoint of the sciences, while general science would select facts and principles from the whole field of science according to the needs of the ninth grade child and endeavor to present this subject matter to the child by such methods as will arouse and hold his interest."

In case neither such course was offered, the question was to be

answered—neither. Below are the answers to the question quoted above together with the data received from the question, "If no general science course was at present offered, is it your plan to do so soon?"

Having elementary science	7 replies
Having general science	69 replies
Having neither	96 replies
Planning to offer it soon	36 replies

The distribution of schools according to high school enrollment furnishing the above data is given below:

Enrollment	*Elementary*	*General*	*Soon*	*Neither*
Under 100	2	14	10	40
100-200	4	30	18	32
200-300	1	13	4	8
300-400		4	2	7
400-500		2	1	4
500-600		1		
600-700		2		
700-800			1	1
800-900				
900-1,000				1
Over 1,000		3		3

In order to facilitate discussion, elementary science will be considered under the head of general science during the remainder of this report.

Our data show that:

I. At least 27% of the 283 accredited schools offer general science.

II. At least 22% of the entire number of high schools in Michigan, 345 in number, offer general science.

III. One half of the schools offering general science are in the North Central Association of Colleges and Secondary Schools.

IV. Assuming that the schools answering "soon" carry out their plans, in the near future, 112 or at least 39% of the accredited schools will be offering the course. Three schools are offering the course for the first time during the second semester of the year 1916-17.

Two instructors volunteered the information that they were offering no such course "because the university does not recognize

it." Five schools report that "we will offer it as soon as it is recognized."

The data from the questions, "In what grade is general science offered?" and "What is the length in years?" are tabulated below:

Grade	Length of Course	Occurrence
9	1 year	40 schools
9	½ "	6 "
9-10	1 "	3 "
9-10	½ "	1 "
9-12	1 "	2 "
10	1 "	3 "
8-9	1 "	3 "
8-9	½ "	1 "
8	1 "	9 "
8	½ "	1 "
7-8	2 "	4 "
7-8-9	3 "	3 "

The above table shows that, as regards to position in the curriculum;

21 courses are below the ninth grade.
59 courses are in the ninth grade.
9 courses are above the ninth grade.

Where the course is in the high school, 51 are 1 year courses and 8 are one-half year courses.

Where the course is below the high school, 15 are 1 year courses, 2 are one-half year courses, 4 are 2 year courses, and 3 are 3 year courses.

In the above three tables, the courses that were offered both in the ninth grade and below were treated as separated courses, as were those appearing both in the ninth grade and above. This explains the discrepancy of more schools answering the question quoted above than the number, 76, that actually have the course.

Two schools, Scottville and Munising, (enrollments 175 and 125 resp.) reported themselves as being on the 6-6 plan (six years elementary school and six years high school). The Scottville course in general science is arranged thus:

Grade 7—elective, reciting 2 forty-five minute periods per week.
Grade 8—elective, reciting 3 forty-five minute periods per week.

Munising reports:

Grade 8—compulsory, reciting 5 forty-five minute periods per week.

Kalamazoo reports 6 schools offering general science, 3 of these have a junior high school of 7, 8 and 9th grades and offering it in each grade. In these schools, the course is distributed thus:

Grade 7—required, reciting 2 forty-five minute periods per week.

Grade 8—elective, reciting 4 forty-five minute periods per week.

Grade 9—elective, reciting 5 forty-five minute periods per week.

In the other three schools, the course is distributed as in the 7th and 8th grades above.

Muskegon (enrollment 1250) reports one 5 year high school. General science is offered in the 8th grade and is continued as organic physiology in the 9th, being compulsory in both grades.

Grand Rapids Central High school (enrollment 1200) reports an elective course offered in 8b and 9a and continued in 9b as physiology, the course being one or three semesters in length.

The answers to the question, "What other sciences are taught in the school, and in what years?", taken from the schools that answered as having general science, are tabulated below. Only high school subjects are considered.

Science	*9*	*10*	*11*	*12*	*Total*
General Science	57	9	2	2	70
Botany	18	32	1		51
Physiography	4	14	2	1	21
Zoology	1	13	1		15
Biology	5	11	1	1	18
Agriculture	2	8	13	7	30
Physiology	2	8			10
Physical Geography	3	4	1		8
Horticulture		1	1	1	3
Greenhouse and Garden Practice		1	1	1	3
Geology			1		1
Chemistry			54	17	71
Physics			17	54	71
Hygiene				2	2
No Course		5	1		6

In addition to the 70 courses of high school general science, there are 2 in the seventh grade and 17 in the eighth grade.

The table should be read: General science is given in the ninth grade in 57 schools, in the 10th grade in 9 etc.—similarly for other

subjects. Many schools offer the same course during different years; such is the case with horticulture and greenhouse and garden practice; 2 schools offer agriculture in each of the high school years. Five offer it for three years and three for two years. The largest number of science courses offered in one year in any school is four. General science is the dominant subject in the ninth grade; botany in the tenth grade; chemistry in the eleventh grade; physics in the twelfth grade. There are as many twelfth grade chemistry courses as there are eleventh grade physics courses. The poor showing of physiography is due to the fact that it is superseded 28 times by general science. We notice that general science ranks third in the high school science curriculum; that it is offered one-fifth as many times as all the high school sciences; and that it occurs three times as often an any other ninth grade science.

The aims and purposes for the course "that have been formulated in order to justify it to school constituencies and pupils", are divided as follows: The number following denote the number of times it was mentioned—some instructors having more than one aim for the course.

I. General science lays the foundation for future science courses—47.

Stimulates interest in science—15

Enables pupils to choose intelligently science courses in the future—8.

Embraces all science—1.

Teaches diction of science—1.

Introduces scientific methods—6.

Good introductory course to specialized science—11.

Shows interrelation between sciences—1.

Removes dread of later sciences—1.

II. General science explains the pupils' environment—31.

Pupils can understand interests in town that depend on science—4.

It gives an understanding of everyday phenomena—10.

Students can appreciate the beauties of nature—1.

Teaches everyday life—10.

Student will find that he can discover things for himself—1.

It is more practical than physiography—1.

Gives general information—is cultural—3.

Pupils will be able to understand scientific papers—1.

III. Those people who do not elect the specialized science courses later or who drop out of high school will nevertheless have some science—19.

IV. Unclassified aims—4.

It is so important that it should have a place—1.

The work is interesting—1.

It discovers whether student leans to science or not—1.

Keeps people in school—1.

The dominant aims, then, of general science are to prepare for the specialized courses, and to explain environment, utilitarian, both of them. Many instructors made much of the third aim, one reporting that it convinced the school board in his city.

The answer received to the question, "What are the advantages of a course in general science?" show that advantages are along the same lines as the aims and purposes. One instructor replied, "The advantages are too numerous to mention." While another enthusiastically declared, that there was not room on the paper to put them all down. Still another reports that general science is such a good foundation for later courses that there may have to be two sections in the later courses, one for the students who have had general science and another for those who have not had it. The advantages are classified below:

I. It is a foundation for later courses—29.

Stimulates an interest in science—12.

Gives general knowledge in science—1.

Prepares people to choose science later—8.

Correlates science—2.

Introduces scientific methods—2.

Make ground work for other science—1.

Introduces a scientific attitude of mind—1.

It makes a quick get-a-way in physics and chemistry—1.

It gives more advancement in higher courses—1.

It dispels the haze that attends the beginning of advanced courses—1.

II. It explains environment—10.

It explains everyday life—9.

Students who take it get an appreciation of nature—1.

III. Unclassified advantages—9.

It covers all the sciences at any time—1.

It has big teaching values—social, intellectual, etc.—1.

Most people have an interest in science at that age—1.
It humanizes the curriculum—1.
It teaches how to study—2.
The course is popular—1.
It keeps people in school—2.

The fact stands out, that the great advantage of general science for the student is that it makes future science easy to him. But we cannot judge from the figures that he is prepared for future science twice as much as his environment is explained to him, for explanation of environment and preparation for future courses undoubtedly go hand in hand in most instances.

Any course which is new in a curriculum naturally has some disadvantages. Below are the limitations of general science.

I. Content—28.
  Scattered information—no sequence—1.
  Cannot be thorough in any one subject—11.
  Too general for specific knowledge—5.
  May lead pupils to think that future courses are as easy—1.
  May be so hard as to kill interest in future courses—1.
  May be bookish—1.
  May go beyond the pupils experience—1.
  Will be repetition of topics for those who go on—1.
  May take away interest for science later on—2.
  May be made too difficult—1.
  There is little of intrinsic worth in the course—1.
  Hard to select topics on which to lay emphasis—1.
  Supersedes physiology—1.
II. Lack of facilities—11.
  Poor texts—1.
  Lack of laboratory facilities—9.
  Lack of properly prepared teachers—1.
III. Administrative—5.
  Curriculum too crowded—1.
  People too young—1.
  Student neglect other work to read up on science—2.
  Sections too large—1.

The dissatisfaction expressed under the heading "Content" is well summarized by one teacher: "Too many bites and not enough chewing." That depends on our aim—Are we trying to teach the

pupil some of each phase of science or are we giving to the pupil an understanding adequate to his needs, of such phases of science as affect his everyday life? Lack of facilities in many schools might as well refer to the other sciences also. But the disadvantages under the last two heads will disappear when general science is firmly established and the content of general science will be adjusted as specific aims are followed.

A state of affairs which is not only true for other subjects as well as for general science, particularly in small schools, is brought to light by the answer to the question, "What other subjects are taught by the general science instructor?" We find that of the 65 general science teachers who replied

2 general science teachers teach no other subject.
15 teach one other subject.
24 teach two other subjects.
13 teach three other subjects.
11 teach four other subjects.

The following table shows what subjects besides general science, 65 teachers handle.

No other subjects—2.
Mathematics—1.
Mathematics and Athletics—1.
Commercial—2.
Other sciences—29.

Other sciences plus one of the following:

Mathematics—9.
Athletics—1.
Commercial—2.
Latin—2.
Public Speaking—1.
English—2.
Literature—2.
Economics—1.
History—1.

Some of the bizarre combinations are due, no doubt, to the limitations of the school program; but many of them seem hard to justify on any grounds. Efficiency in the teaching of science, general or special, or any other subject will be increased as such combinations disappear.

Although general science courses are general in name, sometimes

certain phases predominate. One school reversing the procedure reports that their general science course is scheduled as agriculture. The replies obtained from the question "Does the course refer chiefly to physical, biological or physiographical topics" are shown below:

Phase Predominating	*In high school*	*Below high school*
No particular phase	30 times	4 times
Physiography	9 "	
Physics	8 "	1 "
Physical Geography		1 "
Agriculture	1 "	
Physiography and Physics	8 "	
Physiography and Agriculture	1 "	
Physiography and Biology	4 "	
Physics and Physiology	1 "	
Physics, Physiology and Chemistry	1 "	1 "

Another compilation of the above data shows:

Phase Predominating	*Times mentioned*
Physics	24
Physiography	22
Biology	6
Chemistry	4
Agriculture	2
Physiology	1
Physical Geography	1

One of the administrative problems that must be met when a new subject is introduced in the curriculum is "Shall the course supersede another, or shall it be a distinct addition?" The following table shows how seventy schools answered the question, "What subject, or subjects, did general science supersede?".

Superseded Subject	*In high school*	*Below high school*
Nothing superseded	19 times	8 times
Physiography	28 "	2 "
Physical Geography	5 "	
Geography		1 "
Botany	2 "	
Biology	1 "	
Agriculture	1 "	
Physiography and Botany	2 "	
Biology and Physiology	1 "	

Considering the subjects separately, we find the following:

Subject superseded	*Times mentioned*
Physiography	33
Physical Geography	5
Geography	1
Botany	5
Biology	1
Agriculture	1

We find that, in most cases, sciences that are superseded are not lost entirely in the curriculum as is shown in the following table in which only ninth grade subjects are considered.

Subject	*Times emphasized*	*Times superseded*
Physiography	22	33
Biology	4	1
Agriculture	2	1
Physiology	2	1
Physical Geography	1	5
Geography		1
Botany		5

Seventy-four instructors report the following text:

Snyder—First Year of Science—24.
Hessler—First Year Science—13.
Caldwell and Eikenberry—General Science—13.
Clark—Introduction to Science—11.
Pease—A First Year Course in Science—9.
Weckel and Thalman—A Year in Science—1.
Mayne and Hatch—Agriculture—1.
No text used—2.

The wide difference of general science text book writers on the content of the general science course is shown in the following table, which is a revision of Table I "Number of pages in General Science Texts given to the different special sciences", as given in "General Science in Iowa High Schools" by E. E. Lewis, School Review, June, 1916.

	Hessler	*Clark*	*Snyder*	*Caldwell*	*Pease*	*Weckel and Thalman*
Physics	150	249	67	76	74	51
Chemistry	88	56	10	12	22	59

	Hessler	Clark	Snyder	Caldwell	Pease	Weckel
Biology (Zoology, Botany, Physiology)	178	26	82	131	48	230
Agriculture	10	0	15	15	2	7
Geology	14	0	198	19	83	20
Meteorology	26	0	41	39	12	29
Astronomy	0	0	30	3	31	0
Commercial Geography	0	0	0	8	0	0

Mr. Lewis reports difficulty in distributing material appearing in the texts and that therefore the above table does not accurately show the portions of the book spent on each specialized science. It is, however, sufficient for a rough comparison. We find that, considering all the texts together, they emphasized the phases of science in the order in which they are emphasized in the general science courses in the state, Physiography first, Physics second, etc.

Due to an unfortunate oversight while the questionnaire was prepared, no data are available to show what percentage of the whole number of pupils in the grade elect general science; we can, however, discover how interested the pupils are who do elect the course. In the answer to the question, "How do pupils show an interest outside the class room?", we find the following manifestations of interest and the number of times mentioned.

Perform experiments at home and after school—23.

Request information and explanation—5.

Cite observations of phenomena—12.

Interest in apparatus (wireless, engines, dynamos, manufacturing plants)—6.

Bring specimens to school for identification (and apparatus)—9.

Conversation outside of school—6.

Bring clippings from papers—5.

Outside reading (including systematic reading of scientific magazines)—7.

Asking questions—13.

Pride in note books—1.

Applying principles to phenomena—10.

Suggesting problems and explanations—3.

Formation of science club—1.

Use science subjects in English composition—1.

Students now question what they once took for granted—1.

One instructor declares, that, "there is not enough room on the paper to mention them all."

The above list also shows that the student is really interested in class as well as out of it. From their point of view, they are consciously getting an explanation of their environment. What better reasons for being interested are there than the fact that the principles studied explain things and intimate experiences—building fires, removing stains, keeping afloat in water, how a dynamo runs, etc. Anyone who has taught general science has experienced the joy of seeing pupils really enthusiastic and such enthusiasm, properly guided, can be made to realize any aim that can be formulated.

The following table is compiled from data received in answer to the question, "in what phase are the boys most interested? the girls?". The numbers given refer to the frequency with which the phases were mentioned.

Phase	*Boys*	*Girls*
Machines	1	
Physics	9	4
Chemistry	7	3
Manual Training	1	
Mechanics	1	
Electricity	6	
Practical	2	
Practical Experiments	4	
Showy Experiments		1
Astronomy	1	1
Botany		7
Zoology		2
Physical Geography		2
Domestic Science		10

These figures are not to be interpreted thus; The boys are interested in machines in only one school; rather in this fashion—in one school boys are predominantly interested in machines, being interested in other things also. Similarly for other figures. The table show that the interest of the boys are along the lines that deal with the world in which they are living—the world of industry. The girls, as is somewhat to be expected, are interested in the practical affairs of the home; they also find interest in Botany, Zoology and Physical Geography—subjects which do not appeal to boys so much probably because the practical side of these sciences are not so apparent.

Answers to the question, "Is the course elective or compulsory?" show the following data.

In the high school, ¾ of the courses are elective and ¼ compulsory.

Below the high school, 1-3 of the courses are elective and 2-3 compulsory.

The majority of courses in the high school are elective; the majority below the high school are compulsory.

The following table shows what percentage of students who elect general science are boys and girls.

Per cent. of Boys	*Per cent. of Girls*	*Times reported*
40	60	7
45	55	4
50	50	9
55	45	4
60	40	11
70	30	4
80	20	5
90	10	2

We find that, on the average, the large percentage of students are boys. If we average the percentages and consider all the individual elective courses combined into a large class, we find

Boys	61.4%
Girls	38.6%

The size of sections in general science do not vary very much from the size in other courses. Here are the data.

Number in class	*In high school*	*Below high school*
Below 10	1	
10-14 inclusive	2	
15-19 "	11	
20-24 "	15	5
25-30 "	18	12
31-34 "	4	2
35-39 "	2	
40-50 "		1

We notice that the sections are, roughly speaking, larger below the high school than in the high school, and that, considering the high school courses only, 33 out of the 53 schools reporting have classes between 20 and 30. The data available show that no general state-

ment can be made about the relationship between the size of compulsory and elective courses.

The number of class meetings (including laboratory meetings) per week is shown in the following table.

No. meetings	*In High School*	*Below High School*
5	51	11
4	2	
3		2
2		1

Length of the recitation period is shown below.

Length	*In High School*	*Below High School*
45 minutes	52	6
40 "	4	1
60 "	2	1
20 "	1	1

The data received in answer to the question, "Is a laboratory used in connection with the course?" show that the following interpretations was made by the word "laboratory".

I. Demonstrations made by the teacher in laboratory.

II. Individual laboratory work by students as is carried on in the specialized sciences.

At any rate if we consider that the answer "yes" means that there is some other work besides the work in class, either as laboratory demonstrations or individual laboratory work, we find that

90% of high school courses have laboratory work.

40% of courses below the high school have laboratory work.

10% of the replies from the high school courses stated that they had class demonstrations; 37% of courses below the high school have the same, so we may conclude that all the ninth grade courses have either laboratory or class demonstrations; 77% of courses below the ninth grade have the same.

The manner in which the laboratory is conducted is shown below:

	In High School	*Below High School*
Laboratory demonstrations by teacher	40%	75%
Individual work by students	25%	10%
Both	35%	15%

The following table shows the nature of the laboratory outlines used:

Pease Laboratory Manual	7 times
Caldwell, Eikenberry, and Pieper	9 "
Hessler	7 "
Mimeographed directions	2 "
None	51 "

Of these, the directions are found in the back of Hessler's text; the other two are separate volumes. In the case of the 51 who have no printed instructions, the experiments are in some cases suggested by the text, by the laboratory manuals, of the specialized sciences or by experiments from different general science manuals.

Home experiments are performed by students in 80% of the high school courses, and 66 2-3% of the courses below the ninth grade. Note books are kept in 88% of the courses having laboratory in high school and in 66 2-3% of the cases having laboratory below the high school. The following table shows the length of the laboratory period:

Time in minutes	*In High School*	*Below High School*
40	3	
45	31	6
60	3	1
80	1	
90	1	11

Below are some examples of how some schools divide the time per week in high school general science.

High School Enrollment	*Number of Recitations*	*Length of Recitations*	*No. of Laboratories*	*Length of Laboratory*
133, 335, 70,270	4	45 min.	1	90 min.
45	3	40 "	2	80 "
550	3	45 "	2	80 "
400	4	45 "	1	70 "
250	4	30 "	1	60 "

Number of laboratory periods per week.

Number	*In High School*	*Below High School*
1	15	2
2	20	0
3	2	2
0	4	8
varies	12	2

The following table has been prepared to show the time spent per week on general science.

Minutes per week	*In High School*	*Below High School*
90		3
135		2
200	5	
225	40	5
270	6	
300	3	2
315	3	
330	1	

It will be noticed that there are only a few instances of courses that do not meet at least 5 times a week; that in only one case is the length of the period under 40 minutes. As in the high school courses, 51 are 1 year courses and 8 are ½ year courses, it will be seen that the great majority of cases, at least 120 60 minute hours are spent per year in the course, thereby equalling the time spent in the recognized science courses.

General science is conceded by many to be in an experimental stage. Unlike some other subjects in the high school curriculum that are undergoing changes, it has not yet won recognition by the University of Michigan as a unit for entrance, although the faculty have been considering it for some time; as it now stands, the university is waiting for recommendation from the Schoolmasters' Club. With a view of ascertaining the opinion of the science men (the people who would be qualified to state one way or the other, as they are making the course) on the matter, the question, "Do you believe the general science course to be of such a character as to merit recognition as a unit by the university?" was added to the questionnaire.

One hundred thirteen replies were received to the question; of these 73 were from schools having the course, and 39 from schools not having it. The following table shows the results.

	Schools having course	*Schools not having course*
Yes	67	23
No	5	15
Undecided	1	2

We notice, that the ayes have it by a big majority in schools where the course is found; in schools where it is not found, more

than fifty per cent. are in favor of giving the course recognition. Combining the two columns we have

In favor of recognition—90.
Not in favor of recognition—20.
Undecided—3.

These numbers show that 88% of those who answered the question are in favor of giving it recognition. A bigger percentage in favor of recognition is shown in the case of schools having the course. In those schools, where we must consider that the advantages and disadvantages of general science are actually realized, the percentage in favor of recognition is 91%. That only 3 reported that they were undecided, shows that this question has been rather fully contemplated by those answering. There were many answers that read "emphatically yes", and in other ways showed that the instructors had no doubt about the matter.

The reasons given for thinking that the course should be recognized are as follows:

If the teacher is capable.
Ought to have as much recognition as other science.
Students will take it if the University gives credit.
If the course has a laboratory and is not a hodge-podge.
As course is largely physiography, and physiography was recognized, general science should be recognized.
It has a direct bearing on the observation of normal students.
It is as much an observation, thought and reason developer as any other subject.

The following reasons are given as not being favor of recognition.

There is not enough unity of aim.
It is not standardized.

Of those undecided, all agree that action should be taken at once, in fact, there is a general opinion throughout the state that "something ought to be done about it soon". Some schools are in this position—although they consider the course as good as any other, and it is one that they want to recommend to students, yet they hesitate to do so when the students should be taking work for which he will be getting entrance credit at the University. This is particularly true in schools where the curriculum is crowded.

A complete list of universities and colleges that recognize general science as an entrance unit is not available. Practically all of the

western universities allow a unit of entrance credit for it, as do several of the southern institutions. A partial list of universities recognizing it are—Chicago, California, Northwestern, Nebraska, Arkansas, Mississippi, Alabama, Georgia, Kentucky, Ohio, Iowa, Kansas, and Texas. Several of the universities accept it from students who come from strong high schools.

General science is here to stay; and with university recognition,* high school general science will take the place in Michigan schools that it merits.

The Place and Purpose of General Science in Education[1]

W. G. Whitman, Normal School, Salem, Massachusetts.

In these days of struggle for world democracy, there is a loud call for science and for men with scientific training, but the value of science applied to the development of nations in peace is by no means less than it is for nations at war.

Leaders in education are asking that pupils be taught science at the right time and in the right way. Educators recognize the need of science training and are lending their aid to promote a natural method of studying science. This natural method is the so-called "project method or the method of the science Masters",[2] which is advocated for general science pupils. This is not antagonistic to the scientific method of studying science, which older pupils can use to a greater extent, but it uses the scientific method to the extent that the capacity of the pupil will permit.

It is becoming apparent to men of affairs that they are hampered by their ignorance of the scientific point of view.[3] The merits of many an industrial proposition can only be gauged by one who has a broad view and an appreciation of science.

"Many an elderly professional man, looking back on his education and examining his own habits of thought and of expression, perceives that his senses were never trained to act with precision;

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* The University of Michigan now gives a unit of entrance credit for general science.—Ed.

[1] Paper given before the Science Section of Tufts College Teachers' Association, Oct. 27, 1917.

[2] Woodhull, p. 249, Vol. II, General Science Quarterly.

[3] Little, p. 9, Vol I, General Science Quarterly.

that his habits of thought permit vagueness, obscurity, and inaccuracy, and that his spoken or written statement lacks that measured, candid, simple quality which the scientific spirit fosters and inculcates."[4]

"The devotees of natural and physical science during the last one hundred and fifty years have not shown themselves inferior to any other class of men in their power to reason and to will, and have shown themselves superior to any other class of men in the value or worth to society, of the product of those powers. The men who have done most for the human race since the nineteenth century began, through the right use of their reason, imagination, and will, are the men of science, the artists, and the skilled craftsmen,—not the metaphysicians, the orators, the historians, or the rulers."[5]

Some university scientists are asking that the high schools do more of the science which is now done in college in order that in college they may specialize to a higher degree than at present.[6] Others are asking that more students be interested in science. There has been in recent years a lamentable falling off in the per cent. of students who study science. This fact has given science educators much concern.

Society demands a wider acquaintance with natural phenomena and devices utilizing natural force.[7] We are now surrounded by such an array of science devices in the home, in the shop, in travel, in fact, everywhere, that he who would get the most out of life must have knowledge of many science facts. He who would not appear ignorant in common conversation must look to his science. Ignorance of the explanation of a common application of science was once considered excusable in a man who knew literature and Latin, but today, it is different. He who would contribute his just share to community welfare must understand some of the science which is the basis of good health and sanitation.

We thus see that educators, men of affairs, professional men, scientists, and society are in agreement that science training is proper and essential to the development of a normal member of society.

To these demands for a training in science may we add that

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[4] Eliot, p. 8, Bul., 1916, No. 10, Bureau of Education.
[5] Eliot, p. 12, Bul., 1910, No. 10, Bureau of Education.
[6] Dr. Charles S. Palmer, Mellon Institute.
[7] General Science Manual, Mass. Board of Education. Bul. 81, Page 12.

there is a natural desire for science knowledge on the part of boys and girls who have not met discouragement in their endeavor to learn by the natural or project method.

With all the serious demands made upon our pupils, are we not under obligation to exert our best efforts to lead them to develop into useful members of society? Is it not true that science is a necessary agent in promoting this development? Who will say that science is not essential to an appreciation of our world and of the things which maintain our high degree of civilization? Science is the step-stone of progress; we must give her our best.

Society needs some highly trained specialists as those in the various departments of science, professions and industries and she needs the masses of people who have a more limited but general knowledge and appreciation of science. The science specialist must have long training in the highly specialized details of science. This will usually be obtained in colleges and universities by building upon the science foundation laid in the high school. The more limited general science training of the masses of people will be obtained as a rule before completing the high school course. Both these groups will continue to add to their knowledge long after they have finished their school training. The school training serves largely to fix habits to be followed in later life.

It is important to recognize these two groups and not to impose the exacting requirements of the one upon the other. "Since science has come to be the dominant note in modern life, science itself has the largest part which it has ever held in the history of education. It will use that opportunity or not, determined by whether it faces frankly the problem of using the science of common affairs with which the masses of people deal rather than making the futile attempt of imposing upon people the special aspects of science which are properly of interest to special students."[8]

The science which will meet the needs of the masses in fulfillment of their obligations to society must, of necessity, be drawn from wide fields. There is no special science which may not make some contribution. Because of the broad, general field which this science must embrace, the name *general science* is appropriate and is the name by which such a course is commonly known, though in some localities the names *elementary science* and *introduction to science* are used.

[8] Caldwell, page 135, Vol. I, General Science Quarterly.

Let us now consider briefly the purpose and method of general science. I would state the aim as follows:—to develop in the pupil such an attitude toward nature and toward the products of man's work in utilizing the various materials and forces of nature that there will arise in the pupil a self-impelled desire to carry on studies or investigations about these things in his environment. Let us encourage the pupil to "want to know" about the various science devices in the home, in transportation, in travel, in industry, and about natural phenomena. When a pupil has become so interested in a subject that the incentive to continue the study is so strong that sustained self-activity results, then the pupil has a *project.*

The project is something which a person "throws forward", plans or devises. A science project involves the self-activity of a person in the solution of some problem, in finding the answer to some question, in the construction of some device or the preparation of some material. It involves a desire on the part of the person to carry on the investigation or to make the thing projected. Thus a project is always a self-imposed task. This may be an investigation carried on by an individual member of the class—the individual project—and a report made to the class, or the entire class as a group may become active upon a certain matter, thus making a class project. In a class project it is possible to have different members make individual studies by reading, by questioning, by experimenting, by construction or by other means and bring their reports together in class discussion.

The project method develops originality, initiative, activity, power—all desirable qualities. A project cannot be imposed upon a pupil by the teacher. The teacher can suggest topics or subjects and these may or may not develop into projects. The teacher should strive by encouragement, by all the arts and devices within his power to develop in his pupils that scientific attitude of mind which is alert, which questions, which observes, which reflects, which reasons, which decides,—that attitude of mind which takes a topic or a problem and makes it a real project for intense personal study. This is the kind of school training which gives the pupil real education. This is training the pupil to attack problems in the practical way in which it is done in real life by real scientists. Thus it is that the project method is called the "method of the science masters".

In practice most of us get relatively few of our students to work

upon real projects. Is our effort of no avail when we fail to start projects? By no means. There is unquestioned value in the knowledge of many science facts; there is satisfaction in understanding the explanations of certain phenomena of nature; there is value in acquiring a scientific attitude of mind. The pupil secures much valuable training, knowledge and appreciation whether or not the study reaches the stage where it can rightly be called project study.

But the goal for pupil and teacher is the project study, for then interest becomes fascination and work, which at other times is drudgery, becomes pastime. Those things of value which are the products of a study of topics, are obtained as by-products in project study.

Under the usual school conditions, I do not yet see any way of giving up the study of topics, and substituting in its place a study of projects. The most successful teacher is the one who understands his pupils, their environment, and the vital contacts which pupils make with the science applications in their environment. If he has boundless enthusiasm and inspires his pupils with a love for science, projects will spontaneously arise in the pupils' activities.

Projects are characterized by Prof. Mann. as follows:

"(1) A desire to understand the meaning and use of some fact, phenomenon, or experience. This leads to questions and problems. (2) A conviction that it is worth while and possible to secure an understanding of the thing in question. This causes one to work with an impelling interest. (3) The gathering from experience, books and experiments of the needed information, and the application of this information to answer the question in hand."

The chief aim in general science is not to cover a prescribed list of topics, not to acquire a certain body of science knowledge, but rather to secure a certain attitude of mind toward science, and thereby to develop a scientific spirit. Much valuable knowledge will be gained as a by-product.

In the development of a project a pupil is limited only by his capacity, his available material and his time. It may lead him into any field of science. The natural science project recognizes no artificial special divisions of science. The special sciences of the high school ought not to impose any requirement upon the general science, but rather to build their own courses upon the foundation presented to them.

"Children and adults alike are endowed by nature with the elements of the scientific spirit. The purpose of science teaching is accomplished most successfully when the science classes merely furnish and shape an environment in which the scientific spirit may grow."[9]

Where in our scheme of education can this general science be most effectively taught? Before making a definite answer to this question let us consider the science opportunities of our pupils in the average school at the present time. In the earlier grades, science takes the form of nature study. In some schools, nature study is continued through the eighth and ninth grades. In other schools, no science or nature study is given in the seventh and eighth, or the seventh, eighth and ninth grades. This is largely because of the lack of interest in nature study and the fact that no teachers are available to teach science. In a few schools, elementary special science as elementary physics or elementary botany is taught in these grades, but these subjects have not been very satisfactory. Beginning in the ninth grade or the first year of the high school, special science has been tried, but in the majority of cases it has been abandoned as a failure. Within a comparatively few years, general science has been tried in the first year of the high school with marked success, and the increase in schools adopting this course in phenomenal. In the last three years of the high school, and in four years of some schools, special sciences, as chemistry, biology, physics, geology, and astronomy are taught. These subjects are organized from the standpoint of the mature scientist, and in many instances, represent work too highly specialized for the immature pupil, but for pupils who have had a grounding in the science of common things, these courses are reasonably satisfactory.

As we consider the science training now given the pupils from kindergarten through the high school, it appears that those pupils in the seventh and eighth grades are most poorly cared for. The nature study subject matter and method are fairly satisfactory through the first five or six grades, but in the seventh grade, the pupils are capable of more serious work. They are not ready, however, to plunge into an adult special science. To pupils in the seventh, eighth, and ninth grades, continuation of the usual nature study is

[9] Woodhull, p. 250, Vol II, General Science Quarterly.

like continuing baby talk after one can use real words, while undertaking a special science has the danger of leading to a vocabulary of meaningless words in a narrow field.

As the problem appears to me, we need a course, or a series of courses, which shall bridge this gap in science from nature study of the sixth grade to the special science of the last three years of the high school. This should be broad in its scope, without bounds as to special fields, and cover a period of three years. In the first of these three years, in the seventh grade, the course might well take more of the form of nature study, making a gradual transition from nature study to general science. In the ninth grade, or the first year of high school, it may look forward, somewhat, towards special sciences, again making the transition gradual for those who will continue science.

General science in the elementary school needs expert handling. It is perhaps the most important epoch in the pupils' science training. The beginning of science is of more importance than the ending, "for", says Dr. Dewey, "no amount of pains and ability in the high school can make up for a wrong start or even a failure to get a right start (in science) in the grades".[10] It is therefore highly important that high school science men should interest themselves in the general science problems of the elementary school.

A very large number of our pupils will never get any science in school after the ninth grade and it is highly important to give them the general, useful, interesting science which will make them better citizens. This general science, if given for three years, may well include the physiology and hygiene. Good health and right living are subjects so closely related to many science topics that they may well be carried on together in one course. Many civic questions in the community civics course closely touch the science topics and these two may be worked in correlation. The manual training teacher, if he will co-operate with the science teacher, can work out many of the construction projects with pupils in the shops; as, for example, making motors, telegraph instruments, etc.

Three years of general science is already a fact in quite a large number of schools. Massachusetts is not taking the lead in this movement, however. Superintendents say they believe in it and would like to have it, but they have no teachers who can handle

[10] Page 4, Vol. I, General Science Quarterly.

it. When they feel the need of it so strongly that they will insist that the teachers they hire—normal school graduates—shall be able to teach general science, then the normal schools will prepare general science teachers. Until that demand is made imperative, the normal schools will continue to fit teachers for those subjects which are now in strongest demand. The argument that teachers cannot be supplied for general science work is invalid. If superintendents make the demand strong, a supply will follow. Boston, Rochester, and some other cities are meeting the need by having the science teacher in the system best fitted for the work, train other regular teachers for the work at Saturday classes.

The establishment of the junior high school has given impetus to the three year plan of general science. If the school includes the seventh, eighth, and ninth grades in one system of organization, it makes it easier to handle the general science from the administration side. A science supervisor or director can have charge of the work of the three grades. It is in the junior high schools that the greatest progress has been made in extending general science over a period greater than one year.

We hear some fear expressed about "duplicating this science work in the special sciences later in the high school", that general science is stealing from those courses "the interesting and spectacular feature," thus leaving nothing by which interest in that science can be stimulated. This fear is unnecessary.

In the first place, the majority of pupils who take the general science will not take all the special science later, and there is little danger of any harmful repetition for those who do. If the same subject comes up in the future, the pupil is able to go further in it than before. In general science it is not advisable to attempt to exhaust any subject. Let the pupils go only so far as they can efficiently. There is a limit to their capacities and so a point beyond which it would be unwise to carry them. By following this plan, the pupil never thinks he knows all about a subject. He therefore remains alert to gather more about a subject in the future.

In the second place, a certain amount of duplication is beneficial. It is only by repetition of certain acts that we acquire manual skill. So it is with mental actions. Many important science principles can be understood in no satisfactory fashion without their being repeatedly reviewed and examined from many different view points, so I would call this cry of "danger of duplication" a false alarm.

If the use in general science of a few striking demonstrations from any special science field leaves that science so poverty stricken that it cannot interest the pupils in it, then it is just as well that the pupils do not take it. General science, however, does not depend upon spectacular demonstrations to hold the pupils interest.

The demand for this general science training is gradually becoming more insistent as its value is appreciated.

"The best part of all human knowledge has come by exact and studied observation made through the senses of sight, hearing, taste, smell and touch."[11]

"The elementary school needs to set a definite standard of attainment, not lower or easier but higher and harder, a standard in which the training of the senses shall be an important element."[12]

"Science should be taught in the most concrete way possible—that is, in laboratories, with ample experimenting done by the individual pupil with his own eyes and hands and in the field through the pupil's own observation guided by expert leaders."[12]

Is this general science of interest to colleges? Yes, because the breadth of view gained will be of more value to any pupil who will later undertake a course in special science. Colleges ought to give a unit of credit for a year of high school general science. A number of colleges already do give this credit. The University of Michigan, after considering the question two years, last June voted to give ½ or 1 unit of credit for general science depending upon whether the pupil's course was ½ or 1 year in length. It is to be hoped, however, that colleges will not try to make over the general science course by preparing syllabuses. General science is a high school product and it is best that it remain free from college denomination. It is a course primarily intended for pupils who will not go to college, and yet it is perhaps of equal value to those who do go.

Let me close with a quotation from Dr. Snedden, Former Commissioner of Education for Massachusetts. "In a somewhat general way we are purposing that, by means of education in general science, we shall inspire and assist these youths that they may, in an appropriate degree, take satisfaction in comprehending in other scientific aspects those manifestations of nature, on the one hand, and those works of man, on the other, by which they are environed.

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[11] Eliot, Bulletin 1916, No. 10, Bureau of Education.

[12] Eliot, Bulletin 1916, No. 10, Bureau of Education.

Because of this comprehension we have faith that they will lead better and fuller lives themselves, and will be more companionable and useful members of the larger society in which they are to live as adults. Then, too, we expect that each one will, in a measure, derive from these studies some form of specific knowledge, power, and interest that will guide and reinforce him when he comes to do his share in the world's needed work."[13]

The Story of My Suit:—An Outlined Project

W. W. D. SONES, Schenley High School, Pittsburgh, Penna.

The following outline is intended to be merely suggestive. It serves as a matrix about which a great deal of valuable discussion may be associated. The organization should be in the teachers mind alone, since the elements that are contained therein can readily be developed out of the pupils own experience. Perhaps the class will choose to begin at what has been placed at the end. This should be permitted. However is it usually possible to lead a class in the desired direction by the proper type of questions. Brevity demanded that a bare outline be presented, but, in use a definite teaching plan with questions should be prepared. The exercise may consume a week or a month as desired.

THE STORY OF MY SUIT.

Introduction—What is the purpose of animal coverings?

1. *Protection* as shown in long haired coverings? Feathers in the case of birds, etc. Covering of tropical animals. Covering of "cold blooded" animals.
2. *Sex selection* as illustrated by sex differences in coverings in birds, mammals, etc.

I. Why is clothing worn?

- A. Protection.
  1. From changes in temperature.
     - a. How clothing produces "warmth".
     - b. Heat conductivity of materials used.
     - c. Value of air space—illustrate by building construction, etc.

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[13] Snedden, Problems of Secondary Education, Copyright 1917. Published by The Houghton Mifflin Co.

d. Effect of color on "warmth"—summer versus winter colorings.
e. Loose versus tight weaves.
f. Hygiene of clothing.

2. From wind.
a. Why wind chills. Hygiene.
b. Tightly woven materials for outer garments.

3. From water.
a. Water-proofing materials.
b. Construction of my rain coat.

B. Adornment.

1. Develop the idea of the use of clothing as a determiner of social status. Ill effects of such procedure. Practice of religious sects such as Friends.
2. Clothing for sex attraction. Compare with lower animals. Does "Clothing make the man"?

II. What materials are used in clothing.

A. Animal fibres.

1. Wool.
a. Origin of wool.
b. Preparation for spinning.
c. Characteristic of wool fibre.
d. Spinning the yarn—past and present.

2. Silk.
a. Origin of silk.
b. Preparation for spinning.
c. Special characteristics of silk fibre.
d. Spinning the thread.

3. Fur used for clothing.

B. Vegetable fibres.

1. Cotton.
a. Origin of cotton.
b. The cotton industry in the U. S.
c. The story of Eli Whitney.
d. Characteristics of the cotton fibre.
e. Spinning the thread.

2. Flax.
a. The flax plant.
b. Treatment of flax.

c. Characteristic of fibre.
d. Spinning of linen thread.
3. Other plant fibres.

III. How is cloth woven?
1. Straw weaving of primitive peoples.
2. Principles of weaving—woof and warp.
3. The hand loom.
4. The power loom.
5. Some common weaves—serges, twills, etc.
6. Weaving as a vocation.

IV. How are the colorings secured in cloth?
A. Bleaching.
1. Natural color of the various textile fibres.
2. Home bleaching agents; methods in Colonial times.
3. Chemical bleaching.
a. Treatment of animal fibres.
b. Treatment of vegetable fibres.
c. Effect of chemical agents on durability.
B. Dyeing.
1. Dyeing as practised in the Colonial home.
2. Vegetable dyes; present state of industry.
3. Coal-tar dyes; effect of the war; reason.
4. Commercial dyeing. a. Direct. b. Indirect.

V. How was my suit made?
1. Compare present factory methods with custom tailoring. Interdependence of the various workers who helped to make "my" suit. Tailoring as a vocation. Evolution of clothing.
2. Develop origin of style. Show effects of past customs on present style. What is "fashion". Fashion versus economy.

Laboratory or home exercises.
1. Tests for textile fibres.
a. Alkali test.* b. Odor test. c. Absorbtion of water.
2. Microscopic examination of fibres.
3. Effect of soap with free alkali on woolens.

* This can be motivated by having pupils write to mail-order concerns for samples and check up on catalogue descriptions.

4. Bleaching.
5. Dyeing—direct and indirect.
6. Preparation of vegetable dyes.

Concrete Aids.

The entire exercise permits of instruction in the concrete. Furthermore the materials lay close at hand. Included are:

1. Examinations of the textile fibres in process.
2. The various weaves.
3. Components of soap.
4. Visitations; including custom tailor, dyeing establishment, textile plants, museum for early styles of dress.
5. Bleaching and dyeing agents, etc.

Readings.

Dooley— Textiles. Heath.
Nystrom— Textiles. Appleton.
Tryon— Household Manufactures in the United States. University of Chicago Press.
From Wool to Cloth. American Woolen Co., Boston.
How we make Thread. American Thread Co., Willimantic, Conn.
Hooper— The Loom and Spindle. Smithsonian Inst.
Silk: Origin, Culture, Manufacture. Corticelli Mills, Florence, Mass.
Current general science texts for readings on dyeing and bleaching.

An Applied Science Shop in a Junior School

George R. Miller, Trenton, N. J.

It is slightly more than a year since the opening of the Junior School of Trenton, N. J. It has, among other features of merit, a shop which is perhaps unique in school work.

This shop is forty by sixty feet. Its light comes from windows east, west and overhead. It is equipped with fifteen wood-wording benches, fifteen vises, a pipe vise, forge, two anvils, drill press, gas stoves, soldering irons, emery grinder, and two high-speed lathes. There is also a well equipped tool room to enable the pupils to carry out a wide range of operations in metals.

This shop was established for a variety of purposes, the chief one being the correlation of manual training and the sciences; other purposes were to establish a relation between the school and the home, to foster any initiative or originality that might be apparent in a pupil, and to meet, as far as possible, any demands arising from associations of the boys themselves.

The first of these purposes is met by the construction of physical or other apparatus, some of which is demanded by the school, and others designed by the instructor.

A relation between the school and the home is effected by allowing the pupil to sharpen cutlery, repair agate and tin ware, and to make such minor repairs as may be demanded in any household.

Initiative and originality are encouraged by permitting pupils to carry out ideas that they may have, thus, one believes that he could build a holder for solder that would effect a saving in time and material.

Neighborhood, school, and church associations bring about demands for small things which this shop tries to satisfy.

What follows is a partial list of the things done since our opening: a meter measure, litre can, half pint cup, balance, lever, pulleys, derrick, force, suction and compression pumps, tops, kites, water-level and water-pressure apparatus, pneumatic troughs, metal book-brace, scheme to show ventilation, permanent magnets, sounder, electric motor, electric heater, contact key, and wireless apparatus. Tools for metal and wood are made and repaired, bicy-

cles and "Boy Scout" outfits are kept in order, knives, scissors and hatchets are sharpened, and badges for school and other associations are prepared.

Some of the original schemes had to be abandoned because they were not simple enough; the metre and litre measures and the balance belong to this group. Others such as kites and tops, had to be deferred until the season arrived for their use.

If a pupil has a scheme in his mind, an attempt is made to time it with its place in general science; failing in that, the pupil is accommodated at once so that he may not lose interest in the scheme. This loss of interest is very common; it is sometimes due to the length of time required to bring a scheme to its conclusion, but more frequently due to repeated failures to accomplish the end sought. When loss of interest is apparent the pupil is furnished with a simple piece of work, upon the completion of which he is sure to be ready to take up the work in which he lost interest.

The instructor necessarily decides upon *what* shall be done, but not *how* it shall be done unless the pupil shows that he has no ideas about the work.

The pupils are expected to construct from the raw materials to the finished product in order that they may obtain a wide knowledge of the properties of matter.

Material of Recent Issue Available for General Science

W. W. D. SONES, Schenley High School, Pittsburgh.

There have recently become available for reference work in general science, a number of publications of more than ordinary value. They are to be commended for the saving quality of freshness, which is highly to be desired when we are about the selection of readings for our pupils. Furthermore in material of this nature nothing is presupposed. Everything necessary to the understanding of the topic under discussion, is included, and for this reason, of particular value in project teaching.

1. Lessons in Community and Natural Life. U. S. Bureau of Ed. Sections A. B. C.

   A persual of these leaflets impresses one of the magnitude of

the war and its many ramifications, for they are no less than an attempt to impress upon the school children of America the need for co-operation and conservation. The lessons are of three grades—"Section A for upper classes of the high school, Section B for upper elementary grades and first class in high school, and Section C for intermediate grades. Some of the titles included are: Effect of War on Commerce in Nitrate; Feeding a City; The Aeroplane; A City Water Supply; etc. Price five cents per Section. They can be obtained from Food Administration, Washington.

2. Teacher's Monthly Outline. Popular Science Monthly, New York. Free to Science teachers.

   This outline is designed to assist science teachers who make use of this magazine in their classes. It is to be issued monthly and will be mailed in advance of the publication date of the magazine. This venture promises to serve a real need. The schoolman's point of view is maintained since it is edited by a New York City teacher, Mr. Brownlee.

3. Dixon—Talks on Hygiene. Penna. Dept. of Health. Free.

   Some exceedingly valuable brief paragraphs on personal, home, and community hygiene.

4. Crissey—The Story of Foods. Rand-McNally, Chicago. $1.25.

   Puts in available form some material that has heretofore been inaccessible. It is, as well, easily read by ninth grade pupils.

5. Fisher and Fisk—How to Live. Funk and Wagnals. $1.10.

   This book presents the most recent knowledge about hygiene devoid of pedantry and sentiment. It might well replace most current school texts in this field.

6. The Dawn of the Electrical Era in Railroading. Chicago, Milwaukee, and St. Paul R. R. Chicago. Free.

7. National X-Ray Reflector Co., 235 Jackson Blvd., Chicago. Free.

   How to know and have good lighting.

   Correct lighting for schools.

   How better lighting yields more profits.

Editorials

This has been a year of hardship to periodical publishers. Many have ceased publications until a time when normal prices may again prevail. The expenses of the QUARTERLY for the first year were thirty per cent. greater than estimated. This was in part due to unforseen expenses but largely to increased cost of material and work.

Considering the inauspicious time, from a business point of view, for starting a new venture, the years business has been extremely gratifying. The teachers and advertisers have responded well and the outlook for this year is very promising and we wish to express our deep appreciation to the many who have had the needs of the QUARTERLY in mind, and have contributed to its pages and have obtained new subscribers. Those teachers who wish to show an interest in the continued welfare of the QUARTERLY can help in a very substantial way by increasing the subscription list.

The increase of the subscription prices of magazines has been quite general this year, but it has seemed best for the QUARTERLY to keep its original subscription price and to economize by omitting the frontispiece for a time. Just as soon as financial conditions warrant, the frontispiece will be restored and more cuts used in the text or the number of pages increased. Perhaps all three can be done. It depends upon your own interest and help.

The members of the Advisory Board have helped in many ways. Their counsel has been of great value. Because of their very substantial support the QUARTERLY is not carrying a burden of debt. Any reader whether on the Advisory Board or not is invited to send suggestions, criticisms, and articles for publication at any time. Democracy in a professional science journal is as essential as in a government. We desire this journal to have something worth while to the general science teacher and to the special science teacher.

Let us hear from you.

GENERAL SCIENCE VS. ELEMENTARY SCIENCE.

Is it not possible to reach some agreement in regard to the two terms *general science* and *elementary science?* The distinction made by the teachers in Michigan seems to us admirable and we recommend their point of view for your consideration.

In some schools in grades seven to nine, the science courses are elementary physics, elementary botany, elementary chemistry, or elementary physics and chemistry. Each course separates the science material into the special sciences. Such courses are properly called *elementary science.* Courses in elementary science are taught in New York and in Gary, Indiana.

In some schools in grades seven to nine, the science courses comprise units of study, the development of which is not limited to any special science, but the running over into the various special sciences, which can offer any useful knowledge, is encouraged.

Sometimes one of these units will not involve science material outside one or two special sciences, but the selection of units is not limited to one field. The courses aim at a more general and broad view of the field of science. Such courses are properly termed *general science.* General science is taught in a large number of schools, from Boston to San Francisco.

The term "elementary science" from association with courses which are chiefly special science courses, is suggestive of such courses. It does not suggest at all the use of material from a broad general science field. The term "general science" does suggest the broad field of science and it must be self-evident to any thinking person that it must be elementary and not advanced science. It seems hardly necessary, therefore, to call it *elementary* general science. By common usage, the term "general science" is sufficient to designate an elementary course which is general in its scope.

With the recent growth of general science has come the *project method.* Progressive general science teachers are trying to the best of their ability, to use the project method to some extent in their work. The project method does not fit into the elementary science idea as well as it does into the general science plan, because the solution of a natural problem or evolution of a project may take one far beyond the bounds of any one special science.

CREDIT FOR HIGH SCHOOL GENERAL SCIENCE IN HIGHER INSTITUTIONS.

For some two years the faculty of the College of Literature, Science and Arts of the University of Michigan have had under consideration the acceptance of general science for admission. The matter was brought to a head last spring by the recommendation made by the Michigan Schoolmasters' Club.

The following recommendation passed by the Biological Conference was concurred in by the Michigan Schoolmasters' Club, March 28, 1917:

It is the opinion of the Biological Conference of the Michigan Schoolmasters' Club that general science is worthy of university recognition, because:

1. The subject is adapted to pupils entering high school.

2. It awakens interest in science in a way that the specialized sciences cannot do with young pupils, for it is organized about the common phenomena of daily life.

3. It has the value of preparing pupils for the later sciences in the high school course, and in preparation for life of those pupils who leave school before graduation.

4. It does not make science easy (snap course) rather than thorough; it can be safeguarded, as are other courses, before recognition is granted. Following are the ways in which it may be safeguarded: (a) student, to get credit for general science, should take it before any specialized science course (botany, zoology, biology, physics, chemistry, physiography, hygiene, or physiology); (b) textbooks on general science should contain enough material for one year's work; (c) laboratory work, on the average of two periods a week, should be required; such work may be demonstrations, individual work by students, or field trips. Laboratory records should be kept. There are several very good general science laboratory manuals at present; (d) the general science instructor should be teaching at least one of the specialized sciences in addition to general science, or have had one college course of the physical or biological sciences.

5. General science, in the majority of Michigan high schools, is safeguarded as above.

6. The majority of general science instructors in Michigan believe that it merits recognition.

Therefore, the conference recommends that one unit of entrance credits be given for high school general science to students who come from accredited schools, provided:

1. That the course is a full year's course.

2. That one hundred twenty full, sixty-minute periods are spent on the course, each laboratory period to count as one period of recitation.

3. That laboratory work (consisting of demonstrations, indi-

vidual work, or field trips) on the average of twice a week, is done in connection with the recitation.

4. That for laboratory work there is available equipment used in the specialized sciences, together with what may be needed for general science.

5. That the general science instructor shall, in addition, teach at least one of the specialized sciences, or shall have had one course of college physical or biological science.

It is also recommended that, where the course is half a year in length, it be accepted as one-half unit, if accompanied by one-half unit in physiology, hygiene, botany, zoology, physiography or physiology.

In June, 1917, the faculty of the University of Michigan authorized general science as a half or a whole unit for optional entrance credit.

The following is a statement about credit for general or introductory science made in an announcement of the University of Michigan:

INTRODUCTORY SCIENCE.—One-half or one unit. Instruction in Introductory Science should precede all other courses in science and should preferably be given in the ninth grade.

The aim of this course should be to enable the student to interpret his environment and his relation to it. Teachers of Introductory Science are expected to give instruction also in one of the other sciences and to have had adequate preparation in one physical and one biological science. The ground to be covered by the course should be largely determined by local conditions.

A committee of representatives from the Education and the Science men of the University of Michigan has been appointed to draw up a statement of the preparation advised for teachers of general science.

The vigorous general science movement in California has received a new stimulus in the decision of the State Board of Education to the effect that after August, 1918, all candidates for entrance to the normal schools must have had a course in general science in the preparatory school.

The State Board of Education in Massachusetts for three years has offered examinations in general science for admission to the

normal schools. It is, however, optional, and not a required subject.

A number of colleges now recognize general science among optional subjects for which they give credit.

We hope the day is near at hand when higher institutions will recognize by suitable credit, courses which are distinctly high school courses, that is, those which are not prescribed too minutely by the college. General science is particularly free from college influence, and if college entrance credits can be given without destroying the freedom of capable teachers, well and good. If, however, college acceptance means that the college is to hand down a definite, prescribed syllabus, and thus hamper the teacher who understands the pupils' needs in a given locality better than somebody far removed from the local problem then general science will suffer, and secondary school science will suffer in consequence.

GENERAL SCIENCE NEWS.

PITTSBURGH—The new Schenley High School is well equipped for general science work. There is a lecture or demonstration room, laboratory for individual work and a recitation room. These three rooms are used only for general science classes. The laboratory is equipped for forty pupils, and there are three teachers in the laboratory at one time, with each section of forty pupils. General science is a full year subject with five periods per week. The inductive method is employed and books are used only for reference purposes. This is made possible because of the well equipped school library. The question of a text or texts is as yet undecided. The work is in charge of W. W. D. Sones, who has been interested in general science since 1910.

The Latimer Junior High School, the first junior high school in Pittsburgh to have seventh, eighth and ninth grades in a separate building, opened in September. There are two general science rooms. General science begins in the seventh grade, takes the field of hygiene in the eighth grade, and continues as general science in the ninth grade. Mr. Graham, principal of this school, is much interested in general science and with his assistants will conduct the science work.

A committee of general science teachers representing nine high schools have drawn up a general science syllabus for use in the Pittsburgh schools. It is not yet in print and we have not seen it. On general principles we believe there is danger in such a syllabus. If the syllabus is merely suggestive and does not carry any real or implied compulsion that the teacher follow it, then it may be of real service. But, just as soon as a teacher becomes tied to a definite course, which does not consider the particular individual class with which he is at the time working, then there is danger of losing the vital touch and proper pupil reaction, which makes the difference between mediocre and excellence.

In several of the seventh and eighth grades, general science will be started this year. One great drawback to the science work in a regular seventh or eighth grade room is the lack of space for a permanent demonstration table. It is hoped that soon some apparatus house will put on the market a small, compact demonstration equipment desk on wheels, which can easily be moved into a class room and then removed at the close of the period.

PHILADELPHIA—General Science is strong in Philadelphia. The department heads in the twelve different high schools unanimously voted to introduce a general science course in all the high schools of the city. The course began in September and is called "Introduction to Science."

NEW YORK—Dr. Otis W. Caldwell, the director of the Lincoln School of Teachers College, Columbia University, will have associated with him for the general science work, Mr. Charles W. Finley from Macomb, Illinois and Mr. Earl R. Glenn, formerly of the Carter H. Harrison Technical High School, Chicago.

TRENTON—Principal Wetzel calls the applied science shop, in the Junior School, "the Tinker Shop". This is described by Mr. Miller, the shop instructor, in this issue of the QUARTERLY. Such a shop or one even less pretentious gives the pupils an opportunity to do much of the kind of work recommended by President Eliot in his plea for the development of "well-trained senses and good judgment in using them."

CALIFORNIA—"Western General Science Club" is the name of a new science club recently organized in California. Mr. Percy E. Rowell of San Jose, is president of the club.

PROVIDENCE—At the last meeting of the R. I. Teachers' Science

Association, Mr. Russell S. Lowell, of the Technical High School, was elected president.

New England—At the Spring meeting of the General Science Club of New England, the following officers were elected: President, W. G. Whitman, Normal School, Salem; Vice-President, Mr. J. Richard Lunt, English High, Boston; Secretary, Mr. Geo. C. Francis, Centre School, Everett; Treasurer, Mr. Chas. H. Stone, English High School, Boston; Executive Committee, Mr. Howard C. Kelly, High School of Commerce, Springfield, Miss Edith L. Smith, West Roxbury High School, Miss Mary E. T. Healey, Sherwin School, Boston.

Positions Changed—Mr. G. M. Ruch has accepted a position in the School of Education, University of Oregon. Mr. Percy E. Rowell is in the San Jose High School, California. This year Mr. Harry A. Richardson has changed from Kalamazoo to a Junior High school in Grand Rapids, Michigan. Mr. George M. Turner has left Buffalo and joined the teaching staff of the Boys' Polytechnic High School, Riverside, California. Mr. C. W. Lombard has gone from Leominster, Mass. to the Horace Mann School for Boys, New York.

General Science Books.

General Science Teacher's Manual. Published by the State Board of Education, Boston, Massachusetts, Bulletin number 81. This is a revision of the articles published as the "General Science Bulletin" in volume I of the *Quarterly,* and may be secured free, from the Board of Education, State House, Boston.

Science for Beginners is the title of a new General Science text of 382 pages. "A First Science Book in General Science for Intermediate Schools and Junior High Schools." It is written by Professor Delos Fall, Professor of Chemistry, Albion, Michigan, and is published by the World Book Company, Yonkers, New York.

General Science Quarterly

Vol. II. JANUARY, 1918 No. 2

Science in the War.[1]

J. A. Culler, Miami University, Oxford, Ohio.

These are crucial times in which we are now living. The world has been at war for about three and one-half years. Lord Northcliffe during the last seven months while in this country spent $127 per second, counting all the seconds day and night, for supplies in the interest of the allies. The U. S. in the short space of three months has built 16 cities of 40,000 population in each, has appropriated over 700 million dollars for the building of aircraft, and made numerous other appropriations on the same scale. Mr. Vanderlip calls our attention to the fact that the total expenditures of our government from its foundation, including that of the Civil War, has been only 26 billion dollars as compared with the 19 billion which we are proposing to spend this year alone.

Germany is pushing on in an effort to realize on a contract in which she has bartered her soul in an expectation of gaining the world.

Twenty-one nations of the world have declared war on Germany and have banded themselves together to defeat this monstrous German propaganda.

In a conflict such as this, every means of production and destruction known to man is being used.

Science in the last fifty years has made some wonderful advances. Its aim has been the amelioration of man. To make the work of men more effective. To take the burden off the backs of men and have it carried by natural agencies. To give men more time to devote to matters of spirit so that his plane of life might be higher. Germany is now forcing the world to divert all these great discoveries and inventions to the art of destruction.

Since the beginning of the war, the effort and application of scientists has been very intense. The subjects "Science in the

[1]Paper given before the Physics Section of the Central Association of Science and Mathematics Teachers, at Columbus, Nov. 30, 1917.

War" or "The Effect of War on Science" would be equally interesting and would lead along the same lines of thought. Many things which scientists have been striving to attain have by intense and cooperative effort been pushed ahead thrice as fast as they would have been in times of peace.

We had gasoline motors before the war, but now we have Liberty Motors. This is the product of patriotic men who have pooled their brains and knowledge of motors in the production of one motor which contains all the good points of all the motors.

We had flying machines before the war, but they were slow. To ascend to a height of a mile or so required considerable time,—30 minutes or more. The requirements now for much of the service is a height of 15,000 feet or more in 10 or 15 minutes. Requirements are constantly changing. If we had made up a lot of flying machines three years ago, few of them would be of any use at the front. We could to great advantage have prepared ourselves to meet the demand for raw material such as iron, coal, copper, etc., also such finished products as cars, locomotives, and ships, but it would not have been wise then to put up a lot of finished machines of the kind which science and invention has rapidly changed to meet changing conditions.

We also had motor trucks before the war. Many different kinds of them. They saved France at the battle of the Marne. At that time they were glad to get any kind of truck but it required about 2,000,000 parts to keep them in repair. The solution of this difficulty has been worked out in America where 12 of the best men from motor truck plants and 62 from parts plants met in Washington a short time ago and dumped their trade secrets on the table. Ordinarily in such a meeting each would have been careful to keep to himself any good point which his company had discovered for his machine, but here all was laid on the altar of patriotism and the result is the Liberty Truck, initial orders for 10,000 of which are now placed with 60 different factories. That is the kind of backing most of our manufacturers are giving to this war.

Of course in a time such as this a great many impractical and foolish schemes are brought forward. It is reported that 40,000 different propositions have been sent in to Washington for combating the submarines and doing many other wonderful stunts. These for the most part are from those who have had neither experience nor scientific training,—those who insist on education

being "practical" to the exclusion of fundamental principles. One scheme that lately attracted considerable attention is the use of so called "free energy," whatever that may mean, by a man named Giragossian. By this it is possible to propel air ships and submarines and locomotives around the earth several times without taking on fuel by the way. It solves the whole problem of gasoline and coal shortage and in fact puts to shame all scientific efforts of the past. The claims for the Keely motor hoax in its day were very modest compared with this. It seems rather ridiculous that a committee of Congress would seriously consider a claim of this kind and make a recommendation to Congress, as has been done, that the matter be investigated. Of course a scientist should have an open mind but it should not have to be open very long in propositions of this kind. Such things admonish all of us who are teachers of science to insist more strongly on the great principles of conservation and correlation of energy.

In contrast with this we may mention, as a real and productive, scientific inquiry, the construction at Washington, by proper scientific authority, of a huge receiver of an air pump. It is made of cement, is air tight, large enough to receive the working parts of a flying machine, provided with a refrigeration outfit, and other apparatus necessary to make the test. The purpose is to try out the operation of the machine at a height, say, of 16,000 feet where the air is rare and the temperature low. Thus it is hoped to find answers to such questions as: What style of carburetor is best for these rapidly changing conditions? Will aluminum and other metals retain their tensile strength and other properties when the temperature changes. Will the varnish with which the linen of the wings are filled retain its earth-surface qualities? Thus the conditions of operation in the upper air can be supplied and the necessary material and means of adjustment can be provided. Painstaking work of this kind is where real progress in science is made.

Most of the operations in this war are applications of physics and chemistry. Some of the wars of the past might be called a blacksmith's war, for they fought with spears and swords which were hammered out in the smithy. A battle now, however, is often a conflict of scientifically constructed machines.

Take, for example, the operation of a flying machine. To begin with, there is action and reaction. The propeller drives air in one

direction and in doing so drives the machine in the opposite direction. Then if the machine is tilted up a little in front, a vertical component of force lifts it from the ground and holds it there as long as the machine is in motion. The aeronaut has with him a barometer by which he can tell how high he is. He carries with him, possibly, a Gatling gun and must know how to operate this. He may want to shoot forward in the direction he is moving but there is his propeller and he must not splinter those wooden blades, so that although the blades are moving so fast that he can see only a hazy circle where the propeller is turning yet the synchronizing device with which his rapid firing gun may be provided will send the bullets between and will not hit the blades.

The flier must also know something about photography for it is by this means that a great deal of information is obtained in regard to enemy positions, trenches, movements, etc. That is what is meant by putting out the enemy's eyes. Our feverish production of air machines at this time has for one of its purposes the mastery of the air so that the enemy may not be able to hover over us, take photographs of our lines, or direct the aim of their artillery.

The dropping of bombs from air planes involves a strict application of Newton's first and second laws of motion, the application of which in this work is an art very difficult to attain. If the plane is moving horizontally at the rate of 100 miles per hour, and at a height of 16,000 feet, then, from $s=\frac{1}{2}gt^2$, a bomb let fall would reach the earth in about 30 seconds. During this time the bomb will continue its horizontal motion of 100 miles per hour. If, then, it is dropped when the plane is directly over a building, it would miss the mark by considerably more than three-quarters of a mile.

Then, too, the flier must be provided with a wireless outfit for both sending and receiving, particularly sending, for he can thus give his army warning of impending movements which they cannot see and the gunners must rely on him to tell them when their missiles go beyond, fall short, or go to either side. Often the roar of machinery drowns out sounds of the message he is to receive and so many machines are provided with delicate string galvanometers and, looking through glasses he can read the dots and dashes by the movement of the string.

Beside all this, the flier must know something about astronomy

and the stars for up there it is easy to be lost and the stars at night may help him on his way.

A young man who prepares himself for such work as this, who is sufficiently sound in heart, eye, ear, lungs and brain, and who can go through the grilling experience of a battle in the clouds, certainly deserves at least our highest admiration. We are told in the press of a young man who recently strolled into a New York hotel and wrote on the register the name W. A. Bishop. He did not have an imposing appearance for he is short and weighs about 100 lbs., but it was soon found out that this was Maj. Wm. Avery Bishop who has had bestowed on him every decoration which the British have provided for this kind of service. He has to his credit 110 combats in the air in which he sent 47 enemy machines hurtling to the earth and put 23 others out of commission. He was just then on his way to Toronto to be married and has since been giving help in the aviation fields of this country.

Of course it must be understood in the description given above that there are a variety of styles of machines and that they are equipped in different ways for the different kinds of service which they are to perform.

Principles of physics are also directly applied in artillery practice. The range finder is a delicate optical instrument. The range of the projectile can be calculated from the angle of elevation and the initial velocity, and the height of ascent is found from the same data, also the time of flight, this last being of especial importance in case of shrapnel shells that the fuse may be properly set.

Of course everybody regrets the enormous destruction that must accompany a war of this kind. Destruction of art, property, and life as well as the cessation of that production which would have taken place during the time the war lasts. But even war is not without its compensations. If a result of this war shall be, as we surely think it will be, that the world will be a better place to live in for all time to come, then the nations will be requited for the sacrifice they are now making.

A nation or an individual can often do more in a single year under the spur of a pressing need or a great motive than they would do during several years under ordinary conditions. This is particularly true if that nation has grown rich and has yielded to the allurements of ease and luxury.

The U. S. since the war began, particularly since last April, has been looking itself over as never before. It has been giving itself a severe cross-examination and taking an inventory of its stock and its ways of doing things. This is very desirable at any time but it is seldom done except in times of great stress. A few examples will illustrate this fact. One large establishment has just discovered that they used no corks in their red-ink bottles and the ink has been evaporating, the waste in this amounting to several hundred dollars per year. Another has discovered that they have been extravagant in the use of rubber bands and are now making the necessary retrenchment. In the scarcity of coal, emphatic attention is being directed to hydro-electric plants. The use of electric locomotives on the C. M. & St. Paul R. R. in crossing the Rocky Mountains is saving thousands of tons of coal and oil each year. The power comes from the Great Falls of Montana. Not only is this great amount of fuel saved but each electric locomotive is equal in hauling power to three ordinary ones. These then are released for other work.

Before the war there were only five factories engaged in making dyestuff in this country and their output was small. Now we have 100 such companies which produce not only all the dyes needed here but export more than we formerly imported. Germany has had a monopoly in the dye industry because she managed to make us believe it was her secret, and she is able under her political system to exploit her labor at home and undersell anything we might produce. It is hoped that after the war Germany may be put on the same producing basis as ourselves or that our congress will see the wisdom of keeping this industry at home. Our chemists are eminently able to produce the dyes.

Again, we are finding ourselves short of potash. A German authority said that our going into the war was like a man putting a noose about his neck and allowing them, the Germans, to hold the other end of the rope, for they, he said, had a monopoly of potash and so could dictate what nations should starve and which might have food. So we have been looking about and find that we have various sources of this important ingredient of the soil. The dust from our cement mills and the kelp, sea weeds, growing beneath the water on the Pacific coast will furnish a considerable quantity and chemists tell us that Searles lake in California contains in solution

20,000,000 tons of potash. Our importation from Germany before the war was about one-half million tons per year, and so the potash in this lake would at this rate keep us supplied for about 40 years.

The nitrates also are indispensable in the manufacture of munitions and in fertilizers. The nitrate beds in Chili are nearing exhaustion and the war is forcing the U. S. to look about for new sources of this chemical. Years ago when the great hydro-electric plant at Niagara was started, an attempt was made to form a company for the fixation of atmospheric nitrogen. Capital could not be interested however, and so nothing was done in this country. The Norwegians and Germans copied the proposed process with success. In 1916 the du Pont powder company offered to make a contract with our government and furnish all the capital needed to establish a large plant for the fixation of atmospheric nitrogen, the governmen to permit the use of water power. This was not done. If it had been done we would now be well on our way in the production of all the nitric acid and nitrates we need. We are slow in giving the proper encouragement or subsidies to science in its early stages and to far-seeing men and corporations who make a close study of conditions. Ericsson received no help from our government until after the Monitor had defeated the Merrimac. It is hoped that one effect of this war will be that all of us will have a more liberal attitude in this respect. Congress has lately appropriated under the pressure of war necessity, 20,000,000 dollars for the fixation of atmospheric nitrogen either by the electric arc process or by some other method which a committee of scientific men will recommend.

Any stimulation of the production of potash or the nitrates will assist not only in winning the war but will be very useful afterward in increasing the productivity of the land.

Science makes this war different from all other wars not only in the machines and chemicals used but also in the care of the man. Reports show that about 90% of those who are wounded recover and 40% of them return to the lines. Immediate antiseptic applications and irrigation of deep wounds are in no small degree the cause of this gratifying result.

Deaths from sickness in the army, also, are less than in peace times. This is brought about in two ways. First, sanitary conditions are enforced by men who know what real sanitation is and

thus germs of disease are for the most part avoided. Second, the bodies of soldiers are fortified against disease before they go into service. A soldier is not asked whether or not he wishes to be vaccinated, he is simply vaccinated. Likewise he is fortified against typhoid. There is also an anti-gangrene serum which will further improve matters in this regard.

This is in marked contrast with conditions during the Civil War where more men died from sickness in the camp than were killed in battle.

Of course in a conflict such as this, many must die. It is difficult to find a satisfactory compensation for this, but while the most cherished principles of America and other free nations are at stake, we must be willing to make the sacrifice or go down in history as a nation of cowards. As Secretary Lane has lately said, "It is more precious that America should live than that we Americans should live".

The enthusiastic response of our people to all the appeals of President Wilson gives full assurance that the United States will do her duty.

Science in Modern Warfare.[1]

BY L. L. EDGAR.

The Great War has been called a "grand physical phenomenon" and a "battle of the sciences." To the layman this does not mean very much, but it is nevertheless a fact. It could just as well be called a "chemist's war" or an "engineer's war" or a "surgeon's war," so much have the various sciences contributed toward carrying on the war. Most of us do not think of the part science has played in this great struggle. All we see and read of is the terrible fighting and wastage of human lives. It is very interesting to go into the subject deeper and see what has made possible all this fighting, and just where science and its application has to do with modern trench warfare.

Every known science has played an important role, including chemistry, physics, hygiene, mathematics, engineering, geography, geology, metallurgy, geodesy, bacteriology, meteorology, astronomy,

[1]From November, "Edison Life."

and many more of the physical and natural sciences. The war has demonstrated two things: first, that warfare cannot be carried on without the necessary raw materials, that is chemical, physical and metallurgical supplies; and secondly, it cannot do without the organization of the different scientific elements in connection with the military establishments.

The discovery that such an organization was necessary to the maintenance of war was of prime importance, and it has become essential that each man in a country at war be assigned a task to which he is fitted. At the beginning of the war, the civilians and their advice were not seriously considered by the military authorities. To-day one cannot tell whether the next officer he meets was a soldier before the war or a professor of science in some college. Productive brains receive more care and protection now than any other part of the population.

Let us take some of the more important sciences and see what connection they have in waging war. The astronomer has become an important factor in preparing artillery tables and maps and in perfecting instruments. The statistician is very valuable in planning an offensive, as is also the meteorologist. When trenches are dug, the geologist is consulted, as he can tell the best places for shelter, and the probability of striking underground waters. The leader of the war in France, in the person of the minister of war, is a mathematician, and his personal staff are of the same profession.

The science of acoustics, about which, up to the beginning of the war, very little was known, has blossomed out into that of the greatest importance. The French have in use several systems of determining by acoustics the position of enemy batteries. It is possible by these systems to tell to within a few yards the position of a gun fifteen miles away, to determine its caliber, to tell the difference between the discharge, the flight through the air, and the bursting. The spot from which a shell was fired has been found before the shell landed and exploded. A battery of French thirteen-inch cannon, mounted on a railway truck, fired four shots at an invisible target over fifteen miles away. By means of "sound ranging" and photographs taken the day before from an airplane, the cannon were sighted correctly and the four shots demolished

an enemy battery. Photographs taken after the fourth shot proved it was destroyed. This is only one example of what goes on every day at the front. Just think for a minute what such a feat means. First, an exact knowledge of the region must be known by means of maps. The preparation of these maps is a stupendous task in itself, involving triangulation from various points and photographs from airplanes and balloons. Next, the characteristics of the enemies' cannon must be obtained and their exact positions in relation to their own battery. After each shot the huge cannon must be put back into position. This is done by finely adjusted optical instruments. Then certain correction must be made, due to differences in the weight of the shells, the weight, age, and quality of the charge of powder, and the age, temperature, and state of erosion of the guns. The atmospheric conditions, such as direction, and force of the wind at different heights, the temperature, pressure and humidity of the air all produce disturbances, which must be taken into account and corrected. All this entails an exact knowledge of many of the sciences. In addition to these the shell must explode at the proper instant and must have a proper "fragmentation." All this means exact application of science.

Acoustics are also used in mining operations, in locating airplanes at night, and in submarine detection.

Photography has also been carried to a very advanced stage. Nearly all successful offensives are dependent on correct maps and ranges, and the taking and correct interpretation of aerial photographs has become a military necessity. The French Army have many schools where the training of observers is carried on, teaching the art of taking photos and making maps from them.

Electricity of course has had many applications in warfare, the most important of which is the wireless. Tens of thousands of portable outfits have been made to supply the armies. The success of wireless has been due to the prevention of interference and sorting out of the messages from among the great mass of signals, for during a battle it is a common occurrence for more than fifteen hundred separate stations to send messages simultaneously.

In chemistry, the application has been in asphyxiating gases and tear-producing gases, and of course in the making of gunpowder.

In France alone there are over twenty-five different laboratories engaged in research work on nitrogen fixation.

The weather man, who is not considered to those facetiously inclined very reliable over in the United States, plays an important part. He knows when a gas attack may be expected; he helps the artillery in giving corrections for wind pressures and temperatures; he tells the aviators what winds to expect and their strength; he advises the balloon man; he tells the transports when to expect muddy roads, and the headquarters when to look for rain and fog, and if his information is incorrect a large and well planned attack may be a failure.

In aviation, the remarkable advances during the past few years have been due to the research work carried on in the numerous establishments erected for that purpose.

In addition to the foregoing there are the sciences of medicine, sanitation and surgery. The advances in these have been wonderful. Trench warfare alone has been a new science, bringing with it its employment of scientific research. The supply of munition and maintaining their quality and standard is vital to success. Nothing is so disastrous to an army as premature explosions of its shells.

These examples may give our readers a slight insight into the tremendous magnitude, enormous scope, and far-reaching extent of the problems of modern warfare from the viewpoint of science.

The object lesson to be learned from all this is that for a successful termination of this war, all these sciences and their application, or, in other words, the organizations back of these sciences, must become a harmonious whole, a perfect blending of the many complex and intricate parts with the sole purpose of destroying the enemy. This unity of purpose is the most striking impression received by watching the armies of the Allies.

General Science in Amherst Junior High School.

R. H. Waterhouse, Prin., Junior High School,
Amherst, Mass.

The significant aim of a course in practical science is to acquaint both girls and boys with many of the commonplace experiences of life that are continually transpiring and toward which only a sight-seeing attitude is generally taken. There is a lack of appreciation of the simple mechanical processes and the fundamental phenomena of the universe due to the continuing stress on professional, business, and commercial aims in our schools. If there is evidence of stress in the practical direction at the present time, practicality has smothered the situation. It is provincial as it relates itself to the trade schools. The spectacular career of the vocational school, and its work is proving invaluable, has absorbed our attention. In a rational way now practical training must be given to every girl and boy as well as the few who elect to specialize in it. It must be simple because it is; 1st, fundamental and general, 2nd, no attempt at specialization.

Equipments—The equipment of the manual training room, and the simplest science laboratory equipment, in short a duplication of ordinary conditions will enhance the true value of these lessons. A small cabinet of instruments and tools which may be carried from room to room is economical and desirable. A good text constitutes a good guide to logical procedure and is to be recommended.

Significant Results:—A thoroughly practical, though simple understanding of science involving simple mechanics, physics, chemistry, botany, forestry, geology, astronomy, cookery, and home work is an important contribution to knowledge. Other study will unconsciously be turned into more scientific channels if the pupil handles materials and makes observation of the world as it is. At the same time this kind of science will be a valuable sub-aid to the understanding of all subject matter, and the further realization of what the world really does will stimulate other school activities. We want our girls and boys to have this knowledge of science and

we frankly want them to have a certain degree of skill in elementary handiness which heretofore has been lamentably neglected in public school instruction. Manual training in the form of woodworking is here included. We should aim in the junior high school for a very general course in science. No specific phase of science has enough latitude.

Methods:—With a good text in hand and a systematic outline provided thereby, only general directions become necessary. It is a commonplace, but nowhere more applicable, that the teacher should be profoundly interested in the subject. It would be a serious check to the significant aim of general science if the pupil was not taught that its prime importance lies in the procedure he adopts and the attitude he takes toward any work whatever. A careless habit is not scientific. This is not a book subject and consequently much supplementing with exercises involving tests of observation is necessary. A resourceful teacher will provide a variety of work to demonstrate a wide application of the principles.

The Following is a Two-year Course.

Outline for Girls.

In all science work, conditions actually surrounding the pupils are considered first. One general aim is to acquaint the pupil with her everyday environment and to awaken her to a life of activities that will always present some opportunity for seeing something new and interesting.

Special Aims:

1. To have pupils appreciate nature and to wish to ask questions about natural objects and phenomena.
2. To have pupils acquire a knowledge of facts by experience that will help in their understanding of the natural laws acquired by later study.
3. To help pupils understand their home environment and be interested in conserving home life in all forms.
4. To have pupils acquire a certain minimum of information which will help them to understand other subjects better.
5. To show pupils what improvements can be made in their own homes and the community.

PART I.

HOUSEHOLD SCIENCE.

I. Dust
- a. Composition (Living) (Lifeless)
- b. Object of dusting
- c. Directions for removing
- d. Dust in its relation to the choice of house furnishings.

II. Water
- a. Water as a solvent
  1. impurities (organic, inorganic)
  2. scource of impurities
  3. effect of impurities on the use of water
- b. Characteristics of:
  1. spring water
  2. well water
  3. river water
- c. How to purify water
  1. distilling
  2. filtering
  3. boiling
- d. Effect of heat upon water
- e. Hard water
  1. action of soap
  2. temporarily hard waters
  3. permanently hard waters
- f. Means of softening

III. Artificial aids to cleanliness.
- a. Mechanical agents
  Commercial
  1. Kinds suitable to use in cleaning unfinished wood
  2. Cleaning steel, agate, zinc
  3. Cleaning aluminum
  4. Cleaning brass, copper
  5. Cleaning porcelain
  6. Cleaning silver, gold
- b. Chemical agents in
  1. alkalies
  2. absorbers
  3. solvents

IV. Removal of stains.
  a. Effect of chemicals upon animal and vegetable fibers
  b. Use of acids and alkalies
  c. Effect of washing upon stains
  d. Best time
V. Disposal of waste.
  a. Care of ashes and rubbish
  b. Care of garbage
    1. care of garbage can
    2. cleaning of garbage can
  c. Care of food in the house
    1. storage of perishable food in the refrigerator
    2. storage of fruits and vegetables
    3. storage of groceries
  d. Relations to household pests; harms, cause, prevention, remedy.
    1. flies, mosquitoes, roaches, ants, moths, mice
VI. Sanitation of the house.
  a. Location
  b. Drainage
  c. Foundation
  d. Construction plans
  e. Plumbing
VII. Sanitation as applied to heating.
  a. How air is affected by burning wood, etc., in it.
  b. Fuels: source, composition, fuel value.
    1. wood, 2. charcoal, 3. peat, 4. gas, 5. coal, 6. oil
VIII. Sanitation as applied to lighting.
  a. Candles
    1. history of making candles
  b. Burning of a candle.
    1. necessary elements for burning
    2. explanations of smoke arising after candle has been extinguished.
  c. Burning and care of a kerosene lamp.
    1. the wick and its absorption of kerosene
    2. gas formed before it burns
    3. connection currents and their necessity
    4. control of draft
    5. construction of burner

6. danger from lamp explosion and how avoided

d. Gas: (coal gas and water gas)
   1. substances from which gas may be manufactured
   2. harmful effect of gas and its cause

e. Electricity.
   1. advantages of electric lighting over other means of artificial lighting
   2. fixtures
   3. indirect lighting

IX. Examination of a coal range.
   a. Fire-box, lining, grate, ash-pan
   b. Dampers
      1. main, front damper, check dampers, oven dampers, and chimney dampers
   c. Explain the direction and cause of drafts
   d. Draw an illustration of these drafts.
   e. How to build a fire
      1. combustible materials
      2. arrangement of materials
      3. draft
      4. adjustment of dampers
      5. care needed if kerosene is used

X. The gas range and its management.
   a. Become acquainted with the following parts:
      1. top burners and their regulating cocks
      2. oven burners and their regulating cocks
      3. baking-oven burners and their regulating cocks
      4. broiling oven
      5. oven lighter or "pilot light"

XI. Kerosene stove.
   a. Different types
   b. Care
   c. Management

XII. Home decoration.
   a. Selections of wall coloring to give warm or cool impression
   b. Wall decoration
   c. Arrangement of pictures
   d. Arrangement and selection of rugs
   e. How to brighten a dark room

f. Emphasize the amount and kind of furniture
g. Appropriate furniture for 1. kitchen, 2. dining-room, 3. living-room, 4. bedroom
h. Arrangement of furniture
i. Putting in original "touches"
j. The use of flowers in the house—also on dining table

PART II.

Natural Science.

Natural science may be taught in connection with home garden work. Urge all who are able to care for home gardens. Teach pupils to plan ahead exactly what they wish to work with and then have them carry out their plans accordingly.

In this work photographs of garden plots, trees, flowers, etc., are a great inspiration and help.

I. Diagram of plot of ground showing location of house (if near) and location, shape and size of garden.
  a. Draw to a scale
  b. Aim for original ideas.

II. Plan for flower bed.
  a. Diagram each row exactly
  b. Use one end as a measuring basis
  When planning the flower bed, care must be given to the following features:
    1. Time of blooming
    2. Size of plant
    3. Color of flowers
    4. Amount of foliage
    5. Conditions necessary for best growth

III. Plan for vegetable garden
  a. Diagram of each row or hill
  b. Use one end as a measuring basis.
  In planting vegetables the pupil must have in mind later conditions rather than appearance while growing although the latter must be also considered.

Pupils should make an attempt to plant hardy vegetables at first and care for a few well. The last column gives the distance between rows.

PLANTING SEEDS—FLOWERS.

Plants	*Depth*	*In Row*	*Rows*
Ageratum	¼ in.	6 in.	1 ft.
Alyssum, sweet	½ in.	6 in.	1 ft.
Aster	⅛ in.	¾ in.	1 ft.
Bachelor's Button	¼ in.	6 in.	1 ft.
Balsam	½ in.	1 ft.	1 ft.
Calendula	½ in.	6 in.	1 ft.
Candytuft	¼ in.	6 in.	1 ft.
Carnation	¼ in.	6 in.	1 ft.
Castor Bean	1 in.	4 ft.	4 ft.
Crysanthemum	⅛ in.	¾ ft.	1 ft.
Coboea	½ in.	1½ ft.	along fence
Cosmos	¼ in.	1½ ft.	2 ft.
Cypress Vine	¼ in.	6 in.	along fence
Dianthus	¼ in.	6 in.	1 ft.
Forget Me Not	¼ in.	6 in.	1 ft.
Geraniums, etc.	Plants	1 ft.	1½ ft.
Hollyhock	½ in.	1½ ft.	2 ft.
Hop (Humulus)	¼ in.	1½ ft.	along fence
Kochia (for foliage)	½ in.	2 ft.	1 ft.
Larkspur	¼ in.	1—1½ ft.	1½ ft.
Marigold	¼ in.	1—1½ ft.	1½ ft.
Mignonette	¼ in.	6 in.	1 ft.
Morning Glory, dwf.	½ in.	6 in.	1 ft.
Morning Glory, tall	1 in.	6 in.	along fence
Nasturtium	1 in.	1 ft.	along fence
Pansy	⅛ in.	6 in.	1 ft.
Petunia	⅛ in.	¾ ft.	1 ft.
Phlox	⅛ in.	6 in.	1 ft.
Poppy	⅛ in.	6 in.	1 ft.
Portulaca	¼ in.	6 in.	1 ft.
Salpiglossis	1-16 in.	6 in.	1 ft.
Salvia	¼ in.	1½ ft.	2 ft.
Snapdragon	⅛ in.	6 in.	1 ft.
Stocks	¼ in.	6 in.	1 ft.
Sunflower	½ in.	2 ft.	3 ft.
Sweet Peas	2 in.	6 in.	3 ft.
Sweet Sultan	¼ in.	6 in.	1 ft.
Zinnia	¼ in.	6 in.	1 ft.

PLANTING SEEDS—VEGETABLES.

Proper depth of furrows (usually about four times thickness of seed) in first column; distances apart of plants in row outdoors in second column; distance between rows in third column.

Plant usually 2 or 3 seeds (more if small) near where a single plant is to stand; thin out, when they crowd, to one at each place.

Plants	*Depth*	*In Row*	*Rows*
Beans, bush	1 in.	6 in.	2 ft.
Beans, pole	1 in.	2-3 ft.	3 ft.
Beets	1 in.	4 in.	1 ft.
Cabbage	½ in.	2-3 ft.	2½—3 ft.
Carrots	½ in.	4 in.	1 ft.
Corn	1 in.	6 in.	3 ft.
Kohlrabi	½ in.	½ ft.	1½ ft.
Lettuce, Curled	¼ in.	2 in.	1 ft.
Lettuce, Head	¼ in.	6 in.	1 ft.
Onion Seed	½ in.	4 in.	1 ft.
Onion Sets	1 in.	4 in.	1 ft.
Parsley	¼ in.	6 in.	1 ft.
Parsnips	½ in.	6 in.	1 ft.
Peas	2 in.	6 in.	3 ft.
Potato (tubers)	4 in.	1 ft.	3 ft.
Radish	½ in.	2 in.	3 ft.
Spinach	½ in.	2 in.	1 ft.
Swiss Chard	1 in.	4 in.	1 ft.
Tomato	½ in.	3 ft.	2½—3 ft.
Turnips	½ in.	6 in.	1½ ft.

Cucumbers, 6 or 8 seeds, ½ in. deep to be thinned to 2 or 3 plants, at places.

Muskmelon, Summer Squash, 4 ft. apart.

Pumpkin, Squash, 6 or 8 seeds, 1 in. deep, to be thinned to 2 or 3 plants, at places 6 or 8 ft. apart.

IV. Seeds appropriate for a beginner's garden.

V. Study of seeds and seedlings
   a. Directions for sprouting
   b. Study and compare the seeds and seedlings of the beans, peas, and corn.
   c. Observe and compare other sprouting seeds
   d. Observe the seeds while sprouting and "coming up" and

compare the young plants (seedlings) with what is found in the soaked seeds. Draw the different stages.

1. Try to find from what part of the seed each part of the seedling comes.
2. What parts do seedlings have?
3. Which parts of this little plant do you find ready made in the seed?
    a. The first leaves
    b. The first stem (caulicle)
    c. A part ready to grow the opposite direction and make more stem and leaves (plumule)

Because of the short summer season it is often necessary to start seeds indoors in order to have them mature before fall. Window boxes are good for this work if no hot-house conveniences are possible. Methods of transplanting should be carefully studied so that the plant of seedling will not die when placed out-doors.

The use of cold frames for bulbs in the fall should also be discussed.

VI. Study of parts of mature plant
- a. Roots
    1. Use to plant: a. furnish food materials; b. hold plants in place
- b. The Stem
    1. General description
    2. Use
- c. Leaves
    1. Use
        a. furnish food materials (carbon dioxide)
        b. description
        c. time of growth
- d. Flowers
    1. Purpose
    2. Essential parts
        a. stamens; anthers; filament
        b. pistil; stigma; style; ovary
        c. coralla 1. description 2. purpose
        d. calyx
- e. Fruit
    1. Purpose
    2. How developed

In studying the parts of a flower, different kinds should be examined. The purpose of this is to study fertilization of one flower by another and the different ways in which this is done. Try to get plants which have two distinctly different blossoms e. g. the squash blossom has the staminate blossoms and the pistillate blossoms. The fern is also interesting in its method of reproduction having spores and also root sprouts.

The use of the different parts of the plant should also be emphasized. In some plants we use the root for food e. g. carrots, turnips, etc. In others we use the stem e. g., celery. In others we use the leaves, e. g. lettuce, cabbage, etc. In others we use the blossom e. g. cauliflower. In others we use the buds e. g., herbs for tea and certain kinds of flowers.

VII. Use of plants to man
- a. Food
- b. Beauty
- c. Increase fertility of soil
- d. Purify air
- e. Moderate temperature 1. transpiration 2. shade
- f. Regulate moisture
  1. preserve moisture
  2. prevent evaporation
  3. prevent erosion and so sustain vegetation
  4. regulate stream flow
  5. keep rivers navigable
- g. Fuel
- h. Shelter

VIII. Some objectionable forms of plant life
- a. Weeds
  1. Nature's way of propagation
- b. Poisonous plants
- c. Those which take food materials from necessary plants.

IX. Other enemies of plants
- a. Pests
  1. caterpillars; 2, tomato worm. 3, cut worm. 4, squash bug. 5, potato beetle. 6, rose bug. 7, aphis. 8, elm beetle. 9, brown tailed moth. 10, gypsy moth. 11, borers. 12, codling moth, etc.
- b. Extermination of these
  1. spraying with poison

2. destroying their eggs
3. preserving their natural enemies, which are helpful to man.
    a. almost all birds. b, lady bug. c, frogs. d, dragon flies

The extermination of plant enemies is vital, the pupils must know the manner in which they harm the plant, therefore encourage the pupils to search for these pests or to find traces of their destruction. For example, the work of the potato beetle is commonly known. The cut worm can be found quite frequently and the plant lice, or aphis, are also seen frequently. All these have different methods of working ruin and until these methods are understood, the pupils' attempt at helping the plant will be futile.

Emphasize the fact that one of the best ways to exterminate the enemies of plants is to preserve their natural enemies.

X. Trees
  a. Kinds
    1. Deciduous—trees which lose their leaves in the fall
        a. maple; b, elm; c, oak; d, poplar; e, birch; f, ash
    2. Conifers—trees which do not change appearance during the year.
        a, pine; b, spruce; c, hemlock; d, cedar; e, fir

Different trees have various ways of building. Some have strong end buds while others have strong lateral buds. Let the pupils learn this by examining tree twigs.

Other interesting facts, such as the age of trees, the structure, the grain, etc., should also be taken up.

  b. Enemies
    1. fire. 2, insects. 3, pavements. 4, carelessness of man
  c. Uses
    1. in native state. 2, in manufacturing. 3, in building
  d. Substitutes
    1, metal. 2, cement. 3, composition

PART III.

Astronomy.

Astronomy as studied in the eighth and ninth grades should be a review of planetary geography. This included interesting facts about the sun and its relation to the earth, a slight study of different constellations for recognition, the cause of eclipses, tides, and winds.

I. Comparative age of the earth.
   a. Comparison between different mountain ranges.
   b. Reason given for the variation in age.
   c. Description of the formation of the earth and moon.

II. Relation of the earth to the sun.
   a. Earth's orbit
   b. The seasons as caused by the sun.
   c. Summer and winter
      1. The movement of the earth explains the change of temperature in the different zones.
      2. Corresponding seasons in tropic and frigid zones.
   d. The motions of the earth. (Explanation of day and night.)
   e. The zones.
      1. Tropic—hottest because it receives the vertical rays of the sun
      2. Temperature receives slanting rays of sun;—it is less hot.
      3. Frigid receives very oblique rays of the sun:—it is the coldest.
      4. Explanation of equator and heat equator.

III. The moon.
   a. Cause of different moons.
   b. Movement of moon around the earth.
   c. Physical features of the moon.
   d. Eclipse of Sun.

IV. The planets.
   a. Give a general description of the other bodies moving around the sun.
   b. Learn names of them and be able to recognize them as they appear in the sky.

V. Stars.
   a. Physical nature of stars.
   b. Their source of light and its appearance to us.

VI. Meteors.
   a. Observe shooting stars.
   b. Tell about meteors that people have found. Halley's comet.

VII. Constellations.
   a. Be able to locate and recognize the following constellations.

1, the big dipper; 2, the little dipper; 3, the North star; 4, Orion; 5, Milky way

PART IV.

Physical Geography.

I. Atmospheric pressure.
- a. Definition
- b. Measurement of
  - 1. Use of barometer
- c. Variation with altitude
- d. Effect of pressure on air volume.

II. Winds.
- a. Caused by unequal pressure
- b. Effect on temperature
- c. The velocity of wind
- d. Direction of wind
- e. Meaning of a "High"
  - 1. Causes rise in barometer
  - 2. Means fair weather
- f. Meaning of a "Low"
  - 1. Causes fall in barometer
  - 2. Means stormy weather
- g. The path of "highs" and "lows"
- h. The deflection of winds in the Northern Hemisphere
- i. The general wind system and its prevailing type of weather.
  - 1. Equatorial calms, or doldrums
    - a. hot and moist
    - b. heavy showers
  - 2. Trades

    a, steady; b, showers occur on islands and windward coasts; c, hurricanes; d, cyclones; e, typhoons; f, baguios
  - 3. Prevailing westerlies
    - a. unequal temperature
    - b. highs and lows
  - 4. Polar winds
- j. Land and sea breezes
- k. Monsoons of India.

Outline for Boys.

Special Aims:

1. To inculcate the habit of observation and scientific procedure.
2. To show how this applies to such subjects as mathematics, English, etc.
3. To perform a few exhaustive experiments of varied kinds to show the application. Treatment of the elements, water, air, and fire, will be valuable both for the information and for the exercise. A few actual repair jobs will be necessary in order to teach handiness effectively.
4. To create a desire to be handy-about-the-house.
5. A real science lesson will be more than a exercise—it will have a justifiable object.

I. Scientific Procedure.

II. Study of matter.

- a. The material
- b. The immaterial
- c. Liquids, solids, gases

III. Suggestive outlines.

Note:—The following outlines are offered as suggestions for boys' science. It is assumed that a text will furnish a more specific outline and it is also assumed that local problems relating to industry, commerce, and agriculture will vary.

A. Water.

Introduction:—Water should be recognized in its different states—liquid, solid, gaseous. It is one of the sustaining elements of the universe and upon the other elements—earth, air, and fire—acts for the preservation of mankind. In what everyday ways do earth, air and fire utilize water for man's benefit? In what ways do they combine for his existence? The teacher will be able to give a very interesting demonstration by showing chemically the properties of water.

It is important to study the phases of power dependent on water, the sources of water supply, and the urgent necessity of conserving our forests to this end.

Do not fail to emphasize the reasons for public economy and cooperation in safe-guarding municipal reservoirs.

Simple classroom demonstrations to show physical actions of water are necessary to fix in the pupils' minds such actions as the siphon, hydraulic ram, gravity supply, and water vacuum.

Outline:

1. Life necessity
2. Sources
3. Evaporation:
   a, sun; b, wind; c, stagnation
4. Condensation:
   a, clouds; b, rainfall; c, fog
5. Purification:
   a, boiling; b, distillation; c, filtration
6. Solvent properties:
   a, rocks; b, minerals; c, crosion
7. Physical properties:
   a, weight; b, boiling point; c, freezing; d, liquid (water); solid (ice); gas (steam).
8. Civic systems
   a, wells,—excavated, driven, artesian; b, ponds; c, reservoirs; d, pumping station; e, high and low pressure; f, pumps, siphon, hydraulic ram
9. Meter:
   a, principle; b, reading

B. Heat.

Introduction:—Much useful information, incidental to the subject, should precede the technical subject matter. Pupils are most familiar with the heat generated by fire and the sun. The fire in the house receives comparatively little scientific attention. Teach the economy of clean fires in the range, and furnace, clean smoke pipes, the necessity of fresh air to easy and economical heating, the causes of asphyxiation, the care of heating plants when the fires are out, the cause of the "burned grate," cause of clinkers, kind of coal to use, etc. Mention of illuminating gas and electricity as heating agenices should not be overlooked.

Demonstrate expansion and contraction with simple experiments—using water, air, mercury; and supplementing with allusions to such examples as railway rails, boiler explosions, cleaving ice, and the vacuum barometer. The fundamental tendency in all nature is to generate heat.

Outline:

1. Kind of heat:
   a, natural; b, artificial
2. Common sources:
   a, sun; b, artificial
   1, wood; 2, coal; 3, gas; 4, oil; 5, electricity
3. Common appliances
   a. open fire
   b. brick oven
   c. cooking range
   d. stove
      1, wood; 2, coal; 3, gas; 4, oil; 5, electric
   e. heaters, boilers, furnaces
4. Value
   a. in plant life
   b. in human life (physical)
5. Effects
   a, expansion; b, contraction; c, thermometer

C. Sanitation.

Introduction:—Commonplace topics like the following suggest a most interesting series of lessons. The real argument, however, for the general subject of sanitation is not in the response it may receive because of interest or entertainment but in the urgent necessity of teaching the subject in public schools. Community welfare is the stake.

On the one hand, knowledge of conditions that actually exist, and on the other, the *plain* duty of responsible citizenship, limit the scope of work necessary.

Outline:

1. Personal hygiene:
   a, exercise; b, pure food; c, fresh air
2. Community hygiene:
   a, fumigation; b, quarantine
3. Bacteria:
   a, sources; b, extermination; c, flies; d, milk; e, ice
4. Water supply:
   a, springs; b, wells; c, reservoirs
5. Sewerage:
   a, trap; b, disposal

6. Heating and Ventilation:
   a, steam; b, hot water; c, hot air; d, gas; c, electricity; f, temperature; g, humidity; h, fuel; i, thermostat
7. Diseases:
   a, small pox; b, scarlet fever; c, diphtheria

D. DRUGS.

Introduction:—The predominating aim here is to teach impressively the importance and advantage of a well defined and simple understanding of drugs. Proof experiments with commercial products will prove the best aid.

Outline:

1. Stimulants:
   a, tea; b, coffee; c, cocoa
2. Narcotics:
   a, alcohol; b, morphine; narcotine and cocaine; c, opium; d, chloroform; e, ether
3. Patent Medicine
4. Soothing Syrups
5. Headache Powders
6. Experiment (with small bottle and baby's nipple.)

E. ELECTRICITY.

Introduction:—The service rendered to mankind at the present time by electricity compels our attention every day. Its interesting history and its potential character demands our study. Its part in the drama of life is witnessed now by everyone every day. Surely it is difficult to imagine the human being so isolated that he does not produce or consume a product somewhere affected by this wonderful power.

The purpose of electricity in a general science course is

(1) to make a contribution of practical information to the child's knowledge

(2) to teach the principles of electricity by experience and personal observation

(3) to make the study fundamentally useful for its application and continuance

(4) to develop an inquisitive attitude

Outline:

1. History
   a, Thales; b, Franklin; c, Edison

2. Magnetism
   a, magnetic field; b, polarity; c, the earth a magnet; d, the magnetic needle
3. Forms
   a, lodestone; b, amber; c, silk paper; d, magnet; e, lightning
4. Electric current
   a, batteries; b, battery making; c, circuit; d, direction; e, heating affect; f, electric magnet; g, storage cells
5. Electrical circuits
   a, series; b, parallel; c, combination
6. Wiring cells
7. Methods of house wiring
   a, insulation; b, switches
8. Meters

F. Supplementary Experiment—Fire Extinguisher.

Introduction:—Factories, public auditoriums, and schools must by law be equipped with fire extinguishers. They must be placed near entrances, exits, and stairways, and also in boiler rooms.

An emergency may confront YOU. Knowledge of how to use the fire extinguisher may some time save life and property.

Constantly hold in mind during these experiments that *calmness* is absolutely necessary in an emergency.

Where should the extinguishers be located in this building?

1. *Demonstrate—(Underwriter's model.)*
   Preparations for a fire of paper, excelsior, of small wood should be made on the school lot. Take the extinguisher from its customary place, light the fire, and demonstrate.

   Dismantle the extinguisher by unscrewing the top, removing the head, and releasing the acid container. *Note the process carefully.* Note also the stopper device.
2. Recharge: 1st, fill tank with water up to water mark; 2nd, stir in ¾ pound of soda; 3rd, fill acid container with sulphuric acid, according to directions; 4th, replace acid bottle in carrier and securely fasten; 5th, screw in head; 6th, return to hook, ready for emergency.

G. Supplementary Experiment—Painting House Screens.

Introduction:—With a few simple directions and specifications for materials, boys of this age will be able to get satisfactory results in fixing up the screens at home.

This work would be done more often and consequently prolong the life of the screens if boys knew how to do it. This is another place for boys to become efficient cooperators with their fathers.

Outline:

1. Kinds
   a, copper; b, steel; c, frames (steel, wooden)
2. Season for painting
3. Paint: (for mesh; for frame)
   a, advantages of good quality; b, asphaltum
4. Brushes
   a, 3″ for mesh; b, 1½″ for frame
5. Procedure
   a, repair; b, clean screens thoroughly; c. avoid a dusty room; d, apply thin coats to both sides

H. SUPPLEMENTARY EXPERIMENT—SETTING WINDOW GLASS.

Introduction:—The day should be planned so as to have several sashes brought to the class room. It is advisable to set a small pane first and moreover such a job is likely to be more easily obtained. The sash in a basement or cellar window should be sought. The teacher should demonstrate in the removal of *both* sashes from the conventional casing.

The class may work in groups of three or four.

Emphasize the advantage of accuracy in measurement, neatness with putty and paint, and care to avoid breakage.

Outline:

1. Measure for new light
   a. cut from broken light if possible
   b. glass-plate, rolled
2. Remove sash
3. Remove broken pane
   a. use wide chisel (1½″)
   b. avoid cutting wood of sash
   c. save zinc triangles
4. Set
   a. seal and set bed with film of putty
   b. fasten with triangles
   c. apply putty, avoiding *ripples*
5. Finish when dry or partially so
   a, with paint; b, by cleaning

Ten Lessons on Our Food Supply.

William Gould Vinal, The Rhode Island Normal School.

The writer does not claim originality for any appreciable part of this article. Most of the mathematical facts were gathered by the class in general science,—high school graduates just entering the Normal School. The figures have not been verified and undoubtedly contain mistakes. It is simply written as being suggestive as to the method of teaching this extremely vital subject. All around us we hear discussions of the high cost of living. In our windows we are hanging cards to show that we are members of the United States Food Administration. What can the teachers of our public schools do in this great drive for the conservation of food? The following is a summary of the lessons taught.

Lesson 1. Organization of the Course. At the first meeting of the class the pupils were given a mimeograph sheet telling the terms used in general science and their meaning. Most of these terms and definitions were taken, with some modification, from the General Science Bulletin of the Massachusetts Committee. A few new terms were added. When the class understood the terms they were asked to read the notes on the selection of a general unit and prepare to vote by ballot for the one that they considered most worth while. The vote was almost unanimous for *Our Food Supply.* The following is a copy of the mimeograph sheet:

A. Definitions of Terms.

Education is the preparation for life.

General Science is learning those things in the natural environment which best fits one to meet those problems in life.

A *project* is an organized undertaking to solve some problem. Projects are of two kinds according to their needs:

Individual projects are based upon the definite need or desire of a pupil. (Desk light, electric bell, leakage of gas).

Community projects are based upon the definite need or desire of a group of individuals. (Sewerage disposal, municipal baths, prevention of infantile paralysis).

Projects are of two kinds according to the methods of meeting these needs:

Construction projects are those in which the student or group of students is making or assembling the parts of some mechanical device. (Making a wireless outfit or loaf of bread).

Interpretation Projects are those in which the individual or group of individuals observes or reads to interpret some question or problem. (How the wireless works or the action of yeast).

An experiment is an exercise performed by a pupil to obtain the answer to a problem met in a project.

A *demonstration* is an exercise performed by a pupil or teacher before a class to make clear some fact or principle met in a project.

A *general unit* is a main topic to be developed by projects, experiments, demonstrations, and discussion. (Food, water-supply, fuel, lighting).

A *topic* is usually limited to one subject which is related to a general unit. (General unit, fuel; topics, gas, alcohol, coal, petroleum, safety matches).

The *scientific method* is to make observations from which one may draw a conclusion.

B. Selection of a General Unit.

In selecting a general unit one should keep in mind that it must be (1) worth while, (2) interesting, (3) possible to make observations and do extensive reading, (4) a problem of this locality. The class may select the general unit which they think most interesting and most worth while at this time. Three to six weeks will be spent upon that unit and then another general unit will be selected.

Cleansing and dyeing	Street lighting
Our food supply	Home lighting
Household chemicals	Heat in the home
Baking powders and sodas	Our water supply
Metals used in the homes	Sanitation
Household electrical devices	Ventilation
Uses of electricity in the city	Photography
Building our houses	

Lesson 2. Community Projects in Food Conservation.

The needs of a community may become the needs of a nation or of the world and conversely the needs of the world become the needs

of every community. Not only to make the world safe for democracy but to make democracy safe for the world or for the community the individuals who make up the group should have intelligence as to their responsibilities. As food is the deciding factor of this war the students of the country should become acquainted with the food situation. Fully understanding this the members of the class were asked to make an outline of Lesson 1, in the pamphlet entitled "TEN LESSONS ON FOOD CONSERVATION" published by the United States Food Administration. The following outline was worked out by class discussion and then they were expected to finish it outside of class.

1. *Aims of Course.*
   - (1). Acquaintance with world situation.
   - (2). Definite and immediate things to do.
   - (3). To carry out suggestions.
2. *Causes of Universal Shortage of Food.*
   - (1). *Unkindness of nature.*
     - a. Late springs.
     - b. Droughts.
     - c. Hurricanes.
     - d. Poor conditions of rainfall.
     - e. Unexpected frosts.
     - f. Periods of intense heat.
   - (2). Reduced productivity of soil in Europe.
     - a. Bad management. 1. Withdrawal of men from farms. 2. Overworked women.
     - b. Unskilled work. 3. Unskilled old men. 4. Listless prisoners.
     - c. Lack of fertilizers—sunk by submarines.
3. *Conditions in Germany.*
   - (1). Fats.
     - a. No food is fried.
     - b. Soap a luxury.
     - c. Candles have disappeared.
   - (2). Why Germany has power to endure.
     - a. Four-fifths self supporting before the war.
     - b. A nation given to overeating—reduction a benefit.
     - c. Cultivating Belgium, Northern France, Roumania.
     - d. Intricate food organization.
4. *Position of Allies.*
   - (1). Dependent, even in peace, on importations.
   - (2). Cannot get supplies from Central Europe.
   - (3). Russia—disorganized railroads.

(4). India and Australia.
  a. Shortage of tonnage.
  b. Long distance.
(5). South America—general crop depression.
(6). United States
  a. Greatest food-producing country.
  b. Large acreage in crops.

LESSON 3. LOCAL COMMUNITY PROJECTS.

The study of the plan of the United States Food Administration led to the question: What is being done in Providence to meet the food situation? The class was able to give quite a list of local activities, as—

Canning Demonstrations by the Housewives League at the Arnold Biological Laboratory, Brown University.
Food Exhibit, Roger Williams Park Museum.
Home Gardens. Prizes offered by the Chamber of Commerce.
Faculty Garden of Brown University.
Cooking Demonstrations at R. L. Rose Company.
Freight Embargoes.
Etc.

The projects were listed on the board and the class told to sign their name opposite the one which they wished to investigate. No two were allowed to take the same project.

LESSON 4. THE FUNDAMENTALS OF AN ADEQUATE DIET.

A knowledge of the fundamentals of an adequate diet also becomes a community project at this time. Members of the class were thus asked to make an outline of Lesson IX in the pamphlet mentioned above. An examination was given upon these two summaries.

LESSON 5. THE COST OF BREAKFAST.

This meal was chosen as it is simpler and has a smaller range of variation. This becomes an individual project. In order to standardize results for comparison the following table was presented as a basis.

The pupils were asked to tabulate what they had for breakfast for several days, including the cost, the calories (energy value), and the proteid in grammes (tissue builders). From this data they figured the results for their average breakfast.

Food	Average Weight	(Sept. 28, 1917) Price	Calories	Protein in Grams
Oatmeal	1/4 oz.	$0.00094 (6c lb.)	28.1.	1.08
Corn Flakes	1/2 oz.	.00625 (10c 8 oz.)	51.0	1.25
Banana	3 1/4 oz.	.02500 (30c doz.)	52.8	0.83
Milk	1 glass	.03000	182.5	8.25
	for cereal	.01500	76.0	3.43
	for coffee	.00300 (12c qt.)	15.2	0.68
Coffee	9 grams per cup	.02500 (40c lb.)	00.0	0.00
Sugar	heaping teaspoonful	.001716 (10c lb.)	30.0	0.00
Slice White Bread	1 oz.	.00833 (15c 1 lb. 2 oz.)	75.0	1.86
1 pat butter	1/4 oz.	.00750 (48c lb.)	50.0	
1 medium potato	3 oz.	.01000 (43c pk.)	55.3	0.79
1 egg	2 oz.	.06000 (72c doz.)	93.0	8.75
Bacon, 1 slice	28 grams	.02292 (42c. lb.)	75.9	2.55

Lesson 6. A Comparison of the Cost of Breakfast for the Different Members of the Class.

The investigations of the class in Lesson 5 were now tabulated on the blackboard. Care was taken not to associate names with the cost of the meal, etc., so as to obtain free discussion. A few examples are given:

Student	Cost	Calories	Protein
A	30c	975	30 grams
B	19.9c	411	20 "
C	12.5c	450	9.81 "
D	12.0c	787	18.36 "
G	4.8c	167	18.35 "

General conclusion were derived from the table, such as:—

(1). The price paid for food must not be measured solely in dollars and cents.

(2). Thought and study is needed in planning the dietary.

(3). We need to find what foods will supply the most energy, and the various materials for repairing and building the body at the least cost.

Interpretation projects arose, such as:—

(1). What is the daily food requirement?

(2). What food habits can we change?

(3). What is the cheapest source for our food essentials?

LESSON 7. SOME OF THE REPORTS ON INDIVIDUAL PROJECTS. These developed out of the class discussion in Lesson 6.

(1). *Standard Amounts of Different Nutritive Constituents Required Daily* (Hutchinson, Food and Dietetics).

Protein 125 grams	512.5 calories.
Carbohydrate 500 grams	2050.0 calories.
Fat 50 grams	465.0 calories.
Total	3027.5 calories.

Discussion of rations for children, normal school girls, athletes,

(2). *Table for Estimating the Comparative Cost and Food Value of Fish.* Student visited the Public Market to obtain the prices and studied textbooks for other data. A few of the significant facts reported are given:

Food as Purchased	*Refuse Per ct.*	*Protein Per ct.*	*Calorific Value*	*Market Price*	*Real Cost*
Cod, whole, dressed	29.9	11.1	220	10c lb.	13c lb.
Cod, salt	24.9	16.9	325	13c lb.	15.5c lb.
Herring	?	11.5	825	8c apiece (3/4 to 1/2 lb.)	
Mackerel	44.7	10.2	370	18c. apiece (about 1 lb.)	27c lb.
Halibut	17.7	15.3	475	28c lb.	33c lb.
Salmon, canned	00.0	21.8	915	19c lb.	19c lb.
Salmon, fresh	40.	21.8	915	25c lb.	35c lb.

Some conclusions:

(1). Whole fish, not dressed, are high priced due to the refuse.

(2). The market price is not the real cost.

(3). Herring is a cheap source of energy and protein.

A few interpretation projects that arose.

(1). What use can be made of fish refuse for food?

(2). May fish be used as a substitute for meat?

(3). *Table for estimating the Comparative Cost and Food Value of Meat.*

Food as Purchased	*Refuse Per ct.*	*Protein Per ct.*	*Calorific Value*	*Market Price*	*Real Cost*
Chicken	41.6	58.1	295	35-40c lb.	56c lb.
Fowl	25.9	62.1	775	32-36c lb.	45c lb.
Sirloin	12.8	74.8	985	48-50c lb.	56c lb.
Frankfurts	00.0	88.9	1170	28c lb.	28c lb.
Corned Beef	21.4	65.3	1085	26-28c lb.	31-33c lb.

Conclusions:

(1). Should consider the proportion of edible material when purchasing meat.

(2). Some cheaper kinds are just as nutritious and often less wasteful.

(3). A given amount of money will purchase about seven times the energy in corn beef that it will in chicken.

Interpretations:

(1). Why is the food value of chicken so low and the cost so high compared with fowl?

(2). How may cheaper meats be made palatable?

(4). *Comparison of Prices in the Local Produce Market and the Retail Markets.* Two students visited the farmers' wholesale market on Promenade Street and the retail markets. Results were tabulated on the board, as follows:

Local Produce Vegetable	*Market Price*	*Retail Market Price*	*Large quantities at the same rate*
Apples	\$1.50-2.75 bu.	13c qt.	\$4.16 bu.
Shelled Beans	\$1.75-2.25 bu.	25c ½ pk.	\$2.40 bu.
Pears	\$1.50 bu.	22c qt.	\$7.04 bu.
Tomatoes	\$0.75-\$1.75 bu.	10c qt.	\$3.20 bu.

Conclusions; such as,—In the case of pears the same amount of money will purchase about five times as much in the wholesale market as in the retail.

(5.) *The Cost of Cereal.* Facts tabulated as follows:

Name of Cereal	*Weight per package*	*Price*
Corn Flakes	8 ounces	10c
Force	10 "	10c
Shredded Wheat	12 "	11c
Grape Nuts	14 "	13c
Oatmeal	1 lb. in bulk	6c
Cornmeal	1 lb. in bulk	6c

Conclusions:

(1.) Ready to-eat cereal foods are more expensive.

(2.) Crackers and milk give more nourishment for the same money.

(3.) Cereals are one of the cheapest energy builders.

LESSON 8. NEW FOODS AND METHODS.

A list of supplementary foods and methods were placed on the board, as—soy beans, cow peas, cottage cheese, home-ground wheat in the coffee grinder for a cereal, skim milk, black mussel, dogfish,

puffballs, wrapping green tomatoes in paper for winter use, putting eggs in water glass, drying fruits, preserving greens with salt, cold pack method, cotton seed flour, potato flour, rye bread, etc. Some of these, as canning, were demonstrated. Others might be classed as construction projects, as the making of cottage cheese which is said to have as much protein in one pound as is found in a pound and a half of fowl. The use of soy beans might be an experiment. They are richer and cheaper than other varieties but are not so palatable. Each pupil was asked to select one as an individual project and report to the class.

Lesson 9. A War Breakfast.

The individuals were now supposed to know the war situation in regard to our food supply. They had figured out the daily cost of breakfast. They had gained some knowledge as to the purchasing of foods, and as to the planning of meals that are fundamentally right. They were now asked to plan a war breakfast and compare the data with what they had tabulated for the fifth lesson.

The following was one of the best records. It was not only planned but carried out.

	Price	Calories	Protein
Ordinary Breakfast	20c	461.2	21.0 grams
War Breakfast	10c	1046.8	5.2 grams

Another wrote: "I used bananas on my shredded wheat instead of sugar and used Challenge Condensed Milk in my coffee for the same reason. I had corn muffins instead of wheat bread. I have not used fresh bread in any meal. In this one I have made use of stale bread in a bread pudding."

Lesson 10. Organizing the School into a Working Unit.

This consists of morning talks of about five minutes before the school in the assembly hall. The first talk was by the psychology teacher about "Food Ruts". These talks were on such subjects as, *The Black Mussel.* The black mussel is seldom eaten except by our foreign population. It is more nourishing, cheaper, and more easily digested than the oyster. Volunteers were asked to pledge themselves to support a mussel menu and the shellfish was served in the school lunch room the following day. It is hoped that each object lesson is later carried out in the homes.

The Story of Nitrates in the War.
Ten Lessons.

W. G. Whitman, Normal School, Salem, Mass.

The present war influences our thought and action to such an extent that no wide awake teacher can fail to use some class material which relates more or less to this great world conflict. Among the many vital necessities for carrying on the war, none is more important than the nitrates.

Many facts and principles, related to the nitrates, their production and use are sufficiently simple for seventh and eighth grade pupils. The subject also lends itself to such treatment as will meet the capacities of high school pupils. It is suggested that pupils have a note book in which they record the more important facts and in which they write up the experiments which may be performed as demonstrations. This article is intended to give little more than an outline to suggest some material that may be used in class work. Even if the pupils do not go very deeply into the underlying science, it is possible for them to gain a better appreciation of some of the applications of science to meet the greatest demands the world has ever known.

Lesson 1. Nitrates. Natural Source. Oxidizing Agent. Show speciments of sodium nitrate, potassium nitrate and nitric acid.

Have pupils heard of saltpeter? Chile saltpeter? Discuss deposits of Chile saltpeter. Location. Mining. Purification; formerly sea water was distilled and used, but now pure water is brought from the more distant mountains. Why go so far for water? Why have the deposits been preserved so many years? Exports. Effect of the war upon the industry?

Experiment. Heat sodium nitrate in a test tube and show that it gives off a gas which causes a glowing taper to burst into flame. This gas is oxygen. Potassium nitrate also gives up oxygen when it is heated. Importance of this?

Lesson II. Gunpowder. Show four bottles. The first contains 75 grams powdered potassium nitrate; the second, 13 grams powdered carbon; the third, 12 grams powdered sulphur; and the fourth, a mixture of these three substances in the portions given

above. What experiences and knowledge of gunpowder can the pupils give? What uses?

Experiment. Ignite a teaspoonful of the home made powder taken from bottle four in an iron pan. The carbon burns. The nitrate furnished oxygen for burning. The sulphur combined with the potassium and made the smoke. What objections to a smoke producing powder? Why was there no loud report when the powder burned? What if it had been confined? How are Fourth of July fire-crackers and torpedoes made. How is commercial gunpowder made? Danger. Precaution taken. Forms of powder?

(Optional. Burn a piece of "touch paper" which is held in forceps, this illustrates the burning of a fuse. Touch paper is made by soaking filter or unglazed paper in a solution of potassium nitrate and then drying it).

Lesson III. Explanation of an Explosion. The molecules of gases are always in motion. The molecules of air in a room are incessantly striking the walls and all surfaces. Pressure results from the blows of the millions of molecules.

Experiment 1. Here is a burned out incandescent lamp bulb. There is no air or other gas in it. The air of the room is held apart across this space of 2½ inches by the strength of the glass. The air is exerting about 100 lbs. pressure on each half of the glass globe. If the glass be broken the air will be permitted to come together. Break the bulb by striking it a blow or dropping it upon the floor. Account for the loud report.

Experiment 2. Here is a pop-gun. Inside the barrel the air is exerting the same pressure as outside. Close with the cork. Press the piston in half way. If there is no leakage, the original air has been compressed into one half the space. There are now twice as many molecules pounding on a square inch surface and consequently there is double the pressure. By continuing to push on the piston the pressure inside continues to increase until suddenly the cork flies out with a loud noise.

Experiment 3. Place a candle bomb[1] (½″) on a wire gauze on a tripod. Cover it well with another piece of wire gauze. (It should be placed at some distance from the pupils, at least 5 ft.). Place an alcohol flame or low gas flame under the bomb. While the bomb is being heated explain how water upon boiling changes

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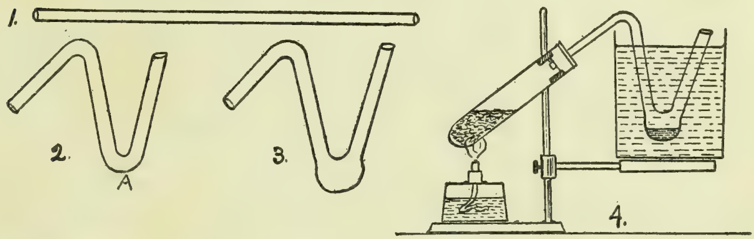
[1]Candle bombs can be obtained from any apparatus dealer.

in volume. One cubic inch of water makes 1700 cu. in. of gas (steam). The candle bomb contains alochol which has a lower boiling temperature than water. As the alcohol is heated, more and more of it changes to a gas, but the gas space in the bomb is very small, so the gas there must be under great pressure. As heat continues, the pressure increases, until finally it is enough to break the glass. Then instantly, this alcohol gas under tremendous pressure, strikes the air with such force that a deafening explosion is the result. Pupils may show graphically in their note books the relative volumes of water and steam by drawing squares in the ratio of 1:1700.

Explain the cause of boiler explosions. Why is such damage done by them?

LESSON 4. NITRIC ACID. Materials needed: A test tube, a one-hole rubber stopper to fit; a 10 inch glass tube; ring stand with clamp; alcohol lamp; beaker or glass tumbler; small evaporating dish; sodium nitrate and concentrated sulphuric acid; stick of artists' charcoal and matches. Bend the glass tube (1) to shape (2). Heat the underside at A until soft and closing one end of the tube with the finger, blow a bulb at A as shown in (3). Prepare this before class time.

Experiment. Making Nitric Acid. Put 10 grams sodium



nitrate into a test tube. Add enough sulphuric acid to barely cover the nitrate. Arrange apparatus as in drawing. Surround the bulb of the delivery tube with cold water in the beaker. Heat the mixture in the test tube, slowly at first, but later strongly enough to produce moderate bubbling. When the bulb is nearly full of nitric acid stop heating. Discuss the experiment. Cause of the bubbling in the test tube? Why cold water is used in the beaker? Source of liquid in the bulb? Show pure nitric acid (colorless). Color of acid made due to a colored gas produced by high temperature in test tube.

Experiment. Oxidizing property. Pour the acid made into the evaporating dish. Heat one end of the slender stick of charcoal until it glows. Thrust the glowing end into the nitric acid. Let pupils tell reason for the active burning. Nitrates have the same stored oxygen as nitric acid. This helps the pupil to understand how gunpowder can burn even though it is confined without air.

Lesson 5. High Explosives. Show five bottles which contain: (1), nitric acid; (2), sulphuric acid; (3), glycerine; (4), absorbent cotton; (5), tar or coal. These bottles contain the materials needed in making some of our most powerful explosives. Millions of pounds of high explosives are being used a day in siege guns, artillery, mines and bombs. Projectiles are hurled for many miles. Glycerin, nitric acid and sulphuric acid when properly treated, produce the liquid, nitroglycerin. This is rather dangerous even with ordinary care. Dynamite contains nitroglycerin, but is safer. Why? Uses of nitroglycerin? Dynamite? Use of explosives in farming? Shooting on oil well.

Cotton, nitric acid and sulphuric acid, when properly treated, produce nitrocellulose. There are different forms of this. The more highly nitrated products make the violent explosive guncotton which is the base of many smokeless powders. Nitrocellulose containing less of the nitrate is used in making collodion and celluloid. Make a list of the articles at home made in part or wholly of celluloid. Why are celluloid articles sources of danger?

Experiment. Hold a piece of moving picture film or celluloid comb in a pair of tongs and set fire to it. Explain cause of the rapid burning.

When coal is "distilled" in producing coke or illuminating gas, tar is a byproduct. When tar is distilled, one of the products is an oily liquid, toluol. Toluol is nitrified and tri-nitro-toluol, called T. N. T. for short, results. Tri-nitro-toluol is one of the most powerful explosives known and is far safer to transport and to use than nitroglycerin. It is extensively used in siege guns, depth bombs for submarines, torpedoes, etc.

Lesson 6. The Army Rifle Cartridge. This lesson is based on an exhibit which may be prepared as follows: Secure a clip of five army rifle cartridges. Remove the bullet from two of these. This is done by securing the cartridge in a vice and gripping the bullet with a pair of pliers; work it loose. Pour the powder from one of the shells into a small pill vial just the size to hold it. Remove

the priming cap from one of the shells. This may be done by pushing the small end of a file into the little hole so that it touches the priming cap, then rest the cartridge on a bolt nut with the priming cap over the hole. Hold the file with pliers and drive it down with a hammer. A light blow is sufficient. With hack saw or file cut longitudinally through the outer metal of one of the bullets removed from the cartridge. Cut off some of the lead inside. File through the outer metal of another bullet which is in a loaded cartridge, so that a metal cap can be removed exposing the lead for a third to half an inch from the end.

Mount the exhibit on a piece of cardboard by wiring the individual pieces to it. The following pieces are suggested.

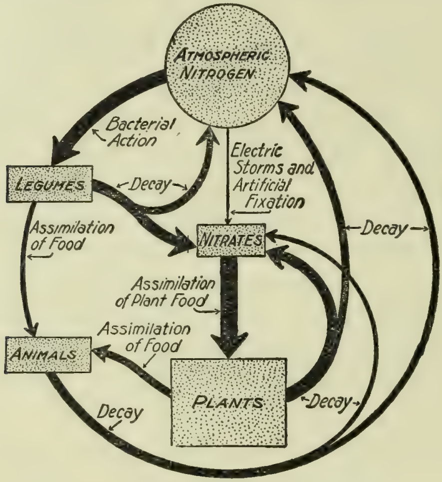
1. The bottle of powder. Exact content of one cartridge.
2. The brass shell with primer removed.
3. The priming cap. This may be glued to the cardboard.
4. The shell with priming cap in place.
5. The bullet.
6. The loaded cartridge complete.
7. The longitudinal sections of bullet, showing harder metal coating.
8. Complete cartridge, but with top of hard metal removed from the bullet. Make a hole in the metal tip and fasten it to the card.
9. The clip which holds the five cartridge, ready for loading the rifle.

Discuss shapes and forms of powder grains. Show pictures. Detonating caps and their use. Distance bullets travel; speed; rifle sights. Compare present bullets with those of Civil war. Dumdum bullets. At 2,000 ft. per second the friction of the air warms the uncapped lead until it is so soft that upon striking a hard body as a bone it will flatten and spatter, making an ugly internal wound.

LESSON 7. FROM NITRATES TO FOODS. One essential food material is that which contains nitrogen. Proteins are tissue builders; they repair worn out tissue. Nitrogenous foods or proteins are in lean meat and various plant foods. Make a list of such foods. Animals which supply the meat got the nitrogen from plants. Plants get nitrogen from the soil. If we remove plant crops year after year and do not return to the soil the things they have taken from the soil, we shall have poor crops.

Nitrogen must be returned to the soil. Commercial fertilizers:

compounds of nitrogen used. Other sources of nitrates besides the deposits in Chile. Nature's way of supplying the soil with nitrogen from the air. Nitrifying bacteria. Denitrifying bacteria. Liming a sour soil to protect the nitrifying bacteria. Crops which



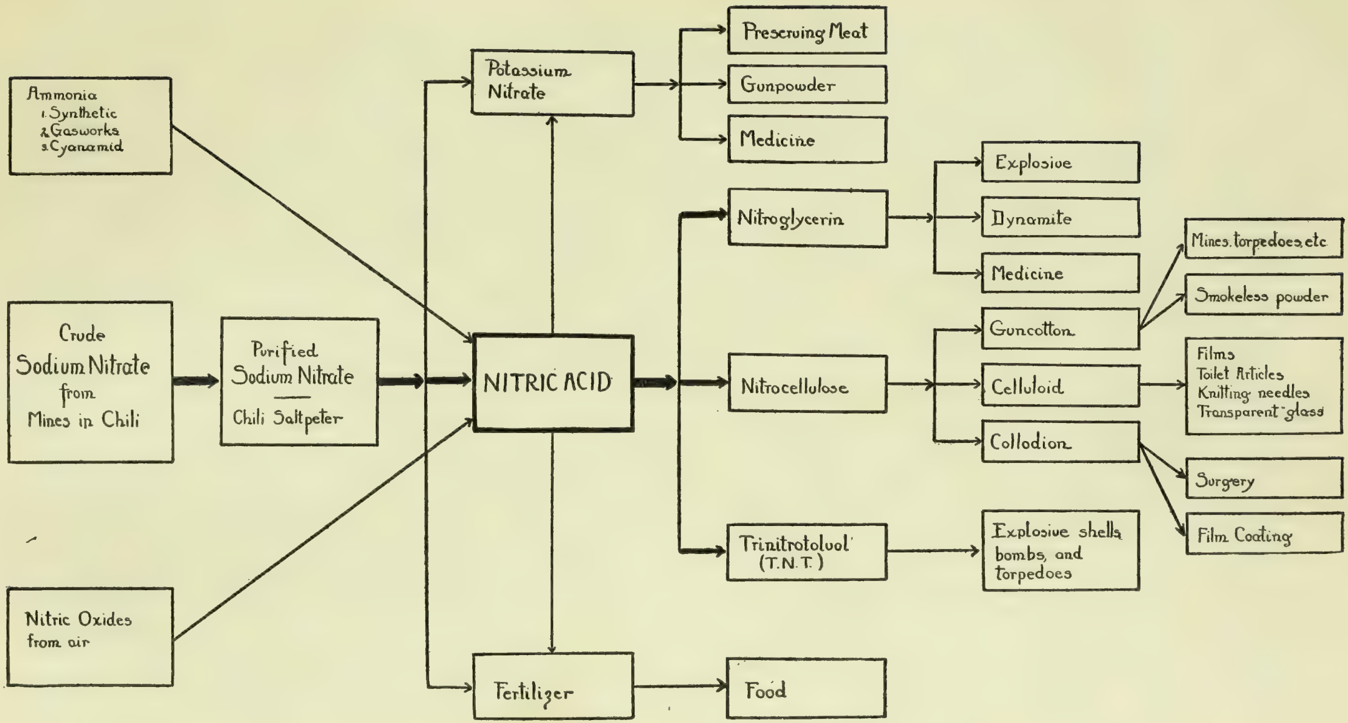
NITROGEN CYCLE *

favor development of nitrifying bacteria. Show pictures or drawings of legume roots with nodules. The cycle of nitrogen. Study the diagram and copy it into the note book. Is this natural process of supplying nitrogen to the soil adequate?

LESSON 8. PRODUCTS DERIVED FROM SODIUM NITRATE. Develop with the class an outline or diagram showing the various compounds and useful products dependent upon the use of nitrates. Pupils make the diagram in their note books. Explain how each of the products is of some value in the war.

LESSONS 9 AND 10. ARTIFICIAL FIXATION OF ATMOSPHERIC NITROGEN. With some classes it may seem advisable to continue the subject of nitrates to show how the United States could continue to make explosives and to provide fertilizer even though the supply of nitrate from Chile were cut off. Synthetic ammonia and its oxidation to nitric acid. Burning nitrogen in the oxygen of the air between terminals of electric arc. Cyanamid and other products. Some material on these topics is found in recent texts and chemical periodicals. Perhaps the best ready source is the pamphlet. "Cyanamid".

* This cut is from Blanchard and Wade's FOUNDATION OF CHEMISTRY. Copyright, 1914. American Book Company.



The Story of Nitrates in the War

Notes on Science Topics Related to the War.

Submarine Problems.

The Naval Consulting Board has issued its first bulletin on "The Submarine and Kindred Problems." The following notes are mainly from that report.

The latest submarine now in use has a surface speed of 17 knots, and a submerged speed of 10 knots. When near the surface the periscope can be raised, an observation taken and the periscope lowered inside of 30 seconds. When the submarine is on surface with uncovered hatches, it takes four minutes to submerge.

The Board is carrying three lines of investigation to combat the submarine menace.

1. *Means of discovering and locating an approaching submarine.* Aeroplanes are the best devise found so far for detecting the submarine when near shore. Sound recording devices are being tested, water is an excellent conductor of sound, and this field is promising.

2. *How to protect cargo ships.* Some use has been made of nets, guards, and screens, but their weight and cumbersomeness prevent easy handling of a vessel in maneuvering in heavy seas. None of these devises yet has the approval of the Navy Department. The best protection of a ship is its speed and maneuvering ability. Another protecting device is in the use of fuels for producing smokeless combustion. Submarines at a distance locate vessels only by smoke which is high in the air.

3. *How to destroy or blind a submarine.* The rapid fire gun has had some success in destroying submarines, but the Board has more faith in the use of heavy charges of high explosives set off deep in the water in the vicinity of the submarine. Such an explosion because of the incompressibility of water exerts such powerful pressure on all neighboring bodies that a submarine if within several hundred feet will be crushed.

The blinding of a submarine is accomplished by using heavy black petroleum which floats on the water. As the periscope passes through the surface of the water it is coated with an oily film which clouds the optical glass. The production of a smoke screen by burning phosphorus or coal tar or by the incomplete combustion

of fuel oil has at times made it possible for ships to escape. Nets have also been laid in which to catch submarines. Tidal action offers a difficulty which has not been entirely overcome in the use of nets.

Submarine bases cannot be destroyed because they are strongly protected by land batteries, aeroplanes, and mine fields.

AEROPLANE FLIGHT RECORDS.

Capt. Guilio Laurzami of the Italian Army recently flew from Turin to Naples and return without stopping, covering 920 miles in 10½ hours.

In June, 1916, Lieut. Antoine Marchal, a French aviator, flew from Nancy, France to Chelm, Russian Poland, a distance of 807 miles.

In November, 1916, Miss Ruth Law flew from Chicago to Hornell, N. Y., a distance of 590 miles. She did this in 5¾ hours. She holds the American long distance, non-stop record.

THE NITRATE INDUSTRY.

Of the world's trade in heavy chemicals, the compounds of nitrogen, nitrate of soda and ammonium sulphate take the lead, reaching as they do into the hundreds of millions of dollars in value. Seven hundred thousand tons of nitrate were used in one year in one smokeless powder plant in the United States. With such enormous need of nitrates, it is not safe at the present time for the United States to depend entirely upon a supply of nitrates from Chile.

There are three important methods for the fixation of atmospheric nitrogen: first in the synthesis of ammonia from nitrogen and hydrogen; second, the combustion of nitrogen in oxygen by the heat of the electric arc; and third, the combination of nitrogen with carbides or metals..

1. Nitrogen is obtained from liquid air and hydrogen is obtained from coal gas. These two are mixed and passed over iron wool—a catalizer—under two or three atmospheres of pressure at 500° C.; the product is ammonia. From the ammonia nitric acid is made by an oxidation process.

It is claimed that the Germans have so perfected this process since the beginning of the war that after the war, it will not be profitable to recover ammonia from gas liquor, because by this new process it can be produced at one-third the cost.

2. At 5500° F. nitrogen will burn in oxygen. When air is

passed between the terminals of an electric arc some of the nitrogen will form nitric oxide. When this gas is cooled to 1150° F. it combines with more oxygen forming nitrogen peroxide. When the peroxide is dissolved in water, nitric acid is formed, and if the peroxide is passed into lime water, calcium nitrate is formed. Calcium nitrate—called Norwegian saltpeter—is manufactured by this process in Norway where electric energy is obtained at low cost from water power.

The acid that is made is very weak. Some of it is concentrated, but more of it is made into Norwegian saltpeter to be used as a fertilizer, or into ammonium nitrate for use in explosives.

There are in the United States experimental plants using this arc process.

3. The United States has taken the lead in fixing atmospheric nitrogen by the use of carbides. A few years ago Professors Frank and Caro tried to produce cyanides by combining nitrogen with barium carbide. They also tried calcium carbide which was cheaper, but instead of making a cyanide they found that a new compound resulted which proved to be calcium cyanamide or lime nitrogen.

At Niagara Falls the American Cyanamide Company have a plant covering forty-two acres. They use water power for generating electricity for their electric furnaces and for power. They make a high grade carbide. The plant is on the Canadian side.

In the electric furnaces the lime and coke become liquid calcium carbide. Three or four times an hour the furnace is tapped and the carbide run off into iron cars where it solidifies. When the carbide is cold it is ground to a dust.

Air is liquified and from this pure nitrogen is obtained.

Four hundred and eighty electric furnaces are used for combining the carbide and nitrogen into calcium cyanamide.

$$CaC_2 + N_2 = Ca\ CN_2 + C.$$

When the cyanamide is treated with steam at high pressure, ammonia gas is given off:

$$CaCN_2 + 3H_2O = 2NH_3 + CaCO_3.$$

By passing the ammonia gas with oxygen slowly over finely divided platinum at 5750°F., nitric acid is made. This is the Ostwald process.

$$NH_3 + 4O = HNO_3 + H_2O.$$

This is the cheapest way to produce *pure* ammonia, and large quantities of it are now being used in making ammonia nitrate for explosives.

Lime nitrogen or calcium cyanamide may be used directly as a fertilizer but without proper preparation there is danger in so using it.

It should be partly hydrated to make sure there is no undecomposed carbide left. It should be made dustless by oiling and then mixed with other fertilizing ingredients.

The ammonia from the cyanamide may be changed to a sulphate, a nitrate, or a phosphate. When ammonium phosphate is mixed with potash salts, a complete fertilizer results, which is much more concentrated than the commercial fertilizer now on the market.

THE NEED OF NITRATES.

During one day of the Somme fighting, the artillery alone used fifteen million pounds of powder.

To make one pound of powder requires three pounds of nitric acid, which is equivalent to four and one half pounds of sodium nitrate. One powder company in the United States used in one year two hundred thousand tons of sodium nitrate.

Chile saltpeter is now our main source of nitrate. Congress has appropriated $20,000,000 for developing the industrial production of nitrates from atmospheric nitrogen. The committee having this in charge recommends that nitric acid be made by oxidation of ammonia, and it has planned to use one-fourth of the sum appropriated at once.

WHY NITROGLYCERIN IS A MORE POWERFUL EXPLOSIVE THAN GUNPOWDER.

When gunpowder explodes, the gas at ordinary conditions of temperature and pressure would occupy three hundred times the volume of the powder. When nitroglycerin explodes, the resulting gas under normal temperature and pressure would occupy twelve thousand times the volume of the nitroglycerin. In both cases, the high temperature at the instant of explosion tends to expand the gas to many times these volumes.

It would require tremendous pressure to hold this gas is a confined space. The larger the volume of gas, the greater the resulting pressure. While both these substances seem to explode instantly, the explosion of the nitroglycerin is much more rapid than that of

gunpowder. This is another reason for the greater force exerted when nitroglycerin explodes.

It is sometimes said that the effective force of nitroglycerin or dynamite, which contains nitroglycerin, is downward, while that of powder is upward. If dynamite and powder were each exploded on the surface of the earth, the dynamite would make a deeper hole in the earth. The comparatively slow rate of explosion of the gunpowder gives the liberated gas time to push away the air. The gases are liberated so rapidly when dynamite explodes that the overlying air cannot be moved away until force has been directed downward. The fact that a larger amount of gas is liberated also tends to produce greater force in all directions.

What is T. N. T? Why is the Supply Limited?

Tri-nitro-toluol, or tri-nitro-toluene, or T. N. T. is a white solid which is easily made and which is safer to use than many other explosives. Chemically it is $CH_8C_6H_2(NO_2)_3$ It is made from toluol and nitric acid. The toluol is obtained as a by-product in the coke industry. There is not enough toluol prepared in this country to supply its present needs. The tar and illuminating gas of the city gas-works contain toluol. By making certain changes in equipment the toluol could be saved. Toluol in gas gives illuminating power, but if gas mantles are used its absence will not be missed. It is of no value in the gas used for heat. It has been estimated that enough toluol is burned in illuminating gas in the United States in *one day,* to make T. N. T. for 150,000 3-inch shells. Three hundred pounds of T. N. T. are used in a single torpedo.

Potash.

It is not ammunition alone that makes a winning army. Food makes the strength of an army. Commercial fertilizers play an important part in the food production of our country. The relative values of the three most important plant foods in commercial fertilizers in the United States is indicated by these figures.

Nitrogen $75,000,000.

Phosphoric acid $65,000,000.

Potash $35,000,000.

At the beginning of the war, Germany had the only ready source of potash, the Stassfurt deposits. Then, potash sold at $35 a ton. Since then, it has sold for $450 a ton. This accounts for the low percentage of potash found in our commercial fertilizers. The

United States is now getting a large amount of potash from sea kelp. It is estimated that there is enough potash in the large deposits of kelp at San Diego, California, to supply our country for agricultural purposes for many years.

A Kelp Farm.

Along the coast of Santa Barbara County, California, the kelp grows in water out to a hundred foot depth. It reaches the surface and runs over the surface of the water. The Government is using sea mowing machines with which it cuts the kelp below the water surface and loads it upon a barge holding a hundred tons. Four crops of kelp can be harvested from one place in a year.

Each hundred tons of wet kelp gives ten tons of dry kelp. The dry kelp is dry distilled in retorts. The nitrogen which passes off is recovered in the form of ammonia. Ten tons of dry kelp yield two and one-half tons of potassium chloride. This is obtained by leaching the residue left in the retorts and evaporating off the water. Other products in this industry are combustible gas and iodine.

Water Power Saves Fuel; Fuel Helps World Democracy.

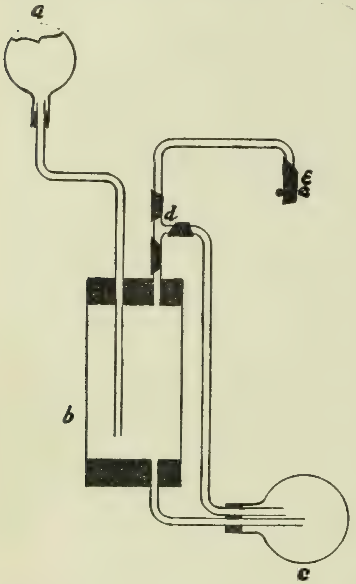
The Chicago, Milwaukee, and St. Paul Railroad is to be operated from Seattle to Harlowton, Montana, a distance of nearly 1,000 miles by electricity. The electric zone now completed is 450 miles in extent. The coal used in locomotives for this distance cost $1,750,000 a year and one-third of the equipment of the road was used to haul the coal. Under the electrified system the cost will be $550,000. No equipment is needed to haul the fuel and 200,000 tons of coal a year will be saved for other uses. The Missoula division formerly burned 425,000 barrels of oil a year. Electrification is now under way in the Cascades which will save 375,000 barrels of oil in addition.

The 200,000 tons of coal is enough to take a United States torpedo boat destroyer 2400 times around the British Isles, or it will supply forty-five destroyers with fuel for a year for active service searching for German submarines.

Hot Water Boiler: Demonstration Apparatus.

OTTO J. WALRATH, HIGH SCHOOL, BLOOMFIELD, N. J.

For those teachers who desire to show the principle of the hot water boiler and the water-front in the kitchen range, the simple set of apparatus shown in the accompanying diagram may prove useful. It is easily put together and is comparatively inexpensive. For the boiler (b) I use a piece of hard one inch glass tubing about two and one-half or three inches long, with a two-hole rubber stopper at the top and a one-hole rubber stopper at the bottom. It is held in place by a clamp attached to a ring stand. (a) is a flask from which the bottom has been removed. It represents the city water system, and serves the double purpose of allowing the addition of water and of allowing expansion when the water is heated in (c). (a) rests in a ring clamped to the top of the same stand by which (b) is held. (c), of course represents the water front. It rests on a wire gauze on a ring held by another stand and is held in place by a test tube clamp attached to its neck. For the water pipes I use small glass tubing. At (d) I use a glass T which is fitted to the other glass tubing with rubber connections. At (e) I use a short piece of rubber tubing, on which I place a clamp so that water may be drawn off occasionally. In order to show the direction of flow of currents, the water placed in (c) may be colored.



New Books.

"An Elementary Study of Chemistry." By McPherson and Henderson. Ginn & Co.

The second revised edition of this popular book is ready. It is an attractive volume full of real chemistry, with an abundance of daily life and industrial applications.

"Every-day Physics." By John C. Packard. Ginn & Co.

This volume of 61 laboratory exercises is unique in providing an introduction to most of the exercises. This gives to the exercises the proper setting which is so often lacking. There are good diagrams. Many of the exercises are admirable for the general science laboratory.

"Experimental General Science." By W. N. Clute. Blakiston's Son & Co.

The author believes that the pupils ought to perform experiments with inexpensive apparatus. At the close of each chapter is a list of questions and suggestive experiments, but the book is so arranged that it can be used entirely for recitations if the teacher so desires.

303 pages. 96 illustrations.

General Science. By Charles H. Lake, Silver, Burdett & Co.

This book is just off the press and is a worthy contribution to the ever increasing number of general science tests. It was written with the needs of the pupils in the Junior High Schools in mind. 454 pages, 400 illustrations.

"Science Teaching." By George R. Twiss. The Macmillan Co. 486 pages. $1.40.

If you are able to add but *one* book to your science library this year, this is the book to add. It has a large amount of helpful suggestions to science teachers. It treats general science with moderation. It has something for science teachers of every kind and creed.

The book is particularly designed as a text for prospective teachers in normal schools and colleges.

Magazine Literature of Interest to Science Teachers.

Agricultural Digest. 2 W. 45 St., N. Y. Monthly. 15c a copy, $1.50 a year.

Good chart suggestions will be found in the MAY NUMBER, page 448 (*Soils*) and the OCTOBER NUMBER, page 663 (*Hygiene*). Articles and diagrams on *Storage of Vegetables* are in the SEPTEMBER and NOVEMBER NUMBERS. In the JUNE NUMBER are a number of interesting illustrations and notes on *"The Life of the Bee."*

Current Opinion. 65 W. 36 St., N. Y. Monthly. 25c a copy, $3.00 a year.

IN THE DECEMBER NUMBER is a short article on Moseley's *"Disclosure of a Secret of a New Atom"* and a description of the latest *German Biplane.*

The Electrical Experimenter. 233 Fulton St., N. Y. Monthly. 15c a copy. $1.50 a year.

THE NOVEMBER NUMBER has an interesting page of pictures of *"Historic Electrical Apparatus"*; Part III of *"The Marvels of Radio-Activity"*; and *"How Big Electrical Men Work"*, which

gives a glimpse of the daily work of De Forest, Pupin and Edison. THE DECEMBER NUMBER explains the transmission of pictures by telegraph. On page 563 is an interesting list of *discoveries "not made by Teutons."* Part IV of *"The Marvels of Radio-Activity"* concludes this series.

Everyday Engineering Magazine. 33 W. 42 St., N. Y. Monthly. 10c a copy, $1.00 a year.

OCTOBER NUMBER. A good article on *"Early Aeroplanes."* The Articles under department heading *"Everyday Aeronautics"* is continued in November and December numbers. *"Testing Milk."* DECEMBER NUMBER. Illustrated article, *"The Caterpillar Tank, What It Is, How It Works." "Household Tests for Meat."*

Garden Magazine. Garden City, N. Y. Monthly. 25c a copy, $2.00 a year.

THE NOVEMBER NUMBER has a practical article on *Greenhouse Heating"* with illustrations of boilers which are exceptionally efficient. There are good sectional diagrams of the boilers and furnace. *"Getting the Garden under Glass"* is another article of particular interest to teachers who have charge of school gardens. There are some helpful suggestions in *"Can you Cook a Potato?"* DECEMBER NUMBER. Those teachers interested in insect pests should read the article on *"Aphids"* by Miss Patch.

The Guide to Nature. Sound Beach, Conn. Monthly. 10c a copy, $1.00 a year.

Every issue of this popular magazine has a chart of the heavens for the current month and an excellent article about the stars by Professor Doolittle of the University of Pennsylvania.

Geographic Review. West 156 St., N. Y. Monthly. 50c a copy, $5.00 a year.

DECEMBER NUMBER. The leading article is an illustrated article on *"Flanders."* 17 pages. A brief account is given (p. 486) of *"A New Theory of the Origin of the Chilean Nitrate Deposits."*.

Illustrated World. Chicago. 15c a copy, $2.00 a year.

JANUARY NUMBER. *"Will you see a great eclipse?"* A four page illustrated article referring to the total eclipse of the sun on January 8, 1918.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly. 50c a copy, $5.00 a year.

FEBRUARY NUMBER. *"Ceramic Industries in the United States."* MARCH NUMBER. *"Production of Light by Animals"* (the fireflies.) This series of articles running through many numbers of the Journal is a revelation of the wonderful light producing power of a multitude of forms of animal life. The theory of light production is discussed.

AUGUST NUMBER. *"Physics of the Air,"* by W. J. Humphreys, U. S. Weather Bureau. Well illustrated. Teachers can read chapter one with profit. Chapters 2 to 4 are too technical. The

subject is continued in subsequent numbers; little of it is of value to teachers. *"Submarines in Periodical Literature"* is a digest of all the important articles in the last six years. It gives in 55 pages much valuable information about submarines and torpedoes.

SEPTEMBER NUMBER. *"Chemistry of Cellulose and its important Industrial Application."* An excellent article offering material suitable for chemistry and general science classes.

OCTOBER NUMBER. *"Development and Progress in Aviation Engines."* A good usable article, has illustrations of engines and different models of aeroplanes.

NOVEMBER NUMBER. *"Studies in Actinochemistry."* This will be continued in future numbers. It is somewhat technical, but on the whole very readable and offers much to high school science teachers.

The Literary Digest. 354 Fourth Ave., N. Y. Weekly. 10c a copy, $3.00 a year.

DECEMBER 15. *"Dishwashing and Disease." "Food in the Forest." "To Fight the Waste of Gasoline."* The last named article has a cut which shows graphically the quantities of gasoline consumed in its various uses.

The National Geographic Magazine. Washington, D. C. Monthly. 25c a copy, $2.50 a year.

THE AUGUST NUMBER contained *"Industry's Greatest Asset—Steel."* Because of its fund of vital scientific and geographical applications, it ought to be read by every high school pupil in the country. There is excellent class material in it. It is 36 pages in length and includes 34 illustrations.

THE OCTOBER NUMBER is *"Flag Number."* Nearly 1200 flags are shown in full colors. Here you may find every flag, pennant and banner in use during the last seven centuries, even showing the most recent flag of the Virgin Islands. The 32 pages of color are in four color work and cost $60,000 to print. This most ambitious achievement of periodical literature has taken two years in preparation and does great credit to the Geographic Magazine staff.

Popular Science Monthly. 239 Fourth Ave., N. Y. Monthly. 15c a copy, $1.50 a year.

THE DECEMBER NUMBER shows an interesting series of pictures illustrating how *serums and vaccines are made for U. S. Army.* The new *self-starting siphon* is explained with a diagram on page 832. In connection with the study of gravity the article *"Breaking the Chain that Binds us to Earth"* is valuable and extremely entertaining. Articles relative to the submarine problem are: *"The Unsinkable Submarine"* p. 840, *"The Smoke Screen* p. 854, *"Camouflage"* p. 876, *"Protecting Battleships with Compressed Air"* p. 886, *"The Submarine Net"* p. 915.

Useful Pamphlets

U. S. FOOD ADMINISTRATOR, Washington, D. C.
"Lessons in Community and National Life." Community Leaflets Nos. 2 and 5. (Section B). Lessons B1 and B5. 5c each; cheaper in quantity.

E. I. DU PONT DE NEMOURS AND CO., Wilmington, Delaware.
"High Explosives," "The Giant Laborer," "Hand Book of Explosives."

THE NAVAL CONSULTING BOARD, 13 Park Row, N. Y.
Bulletin 1. *"The Submarine and Kindred Problems."*

AMERICAN CYANAMID COMPANY, 511 Fifth Ave., N. Y.
"Cyanamid."

CHICAGO, MILWAUKEE, AND ST. PAUL R. R., Chicago.
"The King of the Rails."

MOVING PICTURE FILMS.

THE AMERICAN CYANAMID CO. will loan a film showing the process of manufacturing cyanamid.

THE BARRETT MFG. CO., N. Y. has a film "From Coal to Corn," showing the process of making nitrate fertilizer from the gas liquor ammonia.

The following list of pamphlets, useful as supplementary material in science classes, is submitted by Mr. A. H. Morrison of the Boston Mechanics Arts High School:

Automatic Fire Protection — Gen. Fire Ext. Co., Prov., R. I.

The Tycos Hygrometer. The Barometer Book — Taylor Inst. Co., Rochester, N. Y.

Starrett Memorandum Book — L. S. Starrett Co., Athol, Mass.

Mechanics of the Sewing Machine — Singer Sew. Mach. Co., New York

Directions for Candle Power Determination — Nathaniel Tufts Meter Co., Boston, Mass.

Soldering Kinks — M. W. Dunton Co., Prov., R. I.

Humidity and the Humidostat — Johnson Service Co., 60 Pearl St., Boston

Table of Decimal Equivalents — Chandler & Farquhar Co., Boston

Instructions for the Installation of Copper-Hewitt Lamps — Cooper-Hewitt Electric Co., Hoboken, N. J.

A Chemistry Library for High Schools.

The following books may be bought for Fifty Dollars. They were selected by a committee of the New England Association of Chemistry Teachers. A Twenty-five Dollar list includes those starred (*).

***The Romance of Modern Chemistry.** *J. C. Phillip.* Lippincott.
***Triumphs and Wonders of Modern Chemistry.** *Martin.* Van Nostrand.
***The Chemistry of Commerce.** *R. K. Duncan.* Harpers.
***Chemistry in Daily Life.** *Lassar-Cohn.* Grevel.
***Chemistry of Familiar Things.** *S. S. Sadtler.* Lippincott.
***Chemistry of Common Things.** *Brownlee.* Allyn and Bacon.
***The Chemical History of a Candle.** *M. Faraday.* Harpers.
***The Story of Oil.** *W. S. Tower.* Appleton.
***Chemistry in the Home.** *H. T. Weed.* American Book.
***Pure Foods.** *J. C. Olsen.* Ginn.
***Clean Water and How to Get It.** *A. Hazen.* Wiley.
***Photography for Students of Physics and Chemistry.** *Derr.* Macmillan.
***Textiles.** *W. H. Dooley.* Heath.
***The Story of Iron and Steel.** *J. R. Smith.* Appleton.
***The Story of Gold.** *E. S. Meade.* Appleton.
***A Manual on Explosives.** *Ramsay and Weston.* Dutton.
***The Intepretation of Radium.** *F. Soddy.* Putnam's.
***Modern Science Reader.** *R. M. Bird.* Macmillan.
Modern Chemistry and Its Wonders. *Martin.* Van Nostrand.
Some Chemical Problems of Today. *R. K. Duncan.* Harpers.
The New Knowledge. *R. K. Duncan.* Barnes.
Source, Chemistry and Use of Food Products. *Bailey.* Blakiston.
Chemistry in America. *E. F. Smith.* Appleton.
The World's Minerals. *L. J. Spencer.* Stokes.
History of Chemistry. *F. P. Venable.* Heath.
Coal and the Coal Mines. *H. Greene.* Houghton Mifflin.
Textile Chemistry. *F. Dannerth.* Wiley.
Chemistry of Dyeing. *J. K. Wood.* Van Nostrand.
History of Chemistry. 2 vols *E. Thorpe.* Putnam's.
Physical and Chemical Constants. *Kaye and Laby.* Longmans.
Chemistry in the Service of Man. *A. Findlay.* Longmans.
Chemistry and Its Borderland. *A. W. Stewart.* Longmans.
Laboratory Arts. *G. H. Woollatt.* Longmans.

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General Science in the Junior High School.

By J. C. Loevenguth, Instructor in General Science, Wichita High School, Wichita, Kansas.

Perhaps never before has there been such a demand for the reorganization of secondary education as at the present. While much of the reorganization suggested is along administrative lines, no less urgently perhaps, comes the demand for a change in the subject-matter and in method; also there is a demand for economy of time and not infrequently for no patchwork and no repairs or changes of any kind but a whole new system. Without doubt, the junior high school idea involves some change at least, along all the lines suggested. We have already been cautioned not to get the idea that the junior high school is to be a strip off the old high school and a strip off the elementary school nailed together. Equally important is it for us to remember that it is not to be a high school, nor an elementary school nor a mixture of the two in equal proportions. It is to be a new school with new ideals and a new purpose. For this discussion, we shall assume the school system reorganized on the six-three-three plan and deal with science in the middle of these three groups or what is usually termed the junior high school and includes the seventh, eighth and ninth grades. The discussion will deal with such questions as: "How much science shall be offered and in what years? What shall be the nature of the subject matter? What shall be the method of presentation?

In what year shall the science work be begun? Already, we are told, the seventh and eighth grades are overcrowded with work and there is a demand for more to be added. This being the case, the problem of beginning science or any other high school subject in either of these grades, is by no means an easy one to solve. While we cannot dispute that these grades have enough work to do at the present time, we may well question whether the courses required are what they should be or whether they ought to give place for some other courses. Most of us are willing to agree that the

elementary school should teach the tool subjects, but should eight years be used for such instruction? The monotonous drill work often resorted to in the eighth grade not only is a loss of time, but actually has a detrimental influence on the boys and girls. Such subject-matter as the puzzles in arithmetic and the technical grammar with which the elementary school is often burdened during these grades, has little place in the life of a pupil in the grades. The adolescent period is a responsive period and much of the work given in the grades during this period is not fruitful enough of suggestion and activity. This is not a time when the student cares to rack his brain over non-essential material or to waste his time with uninteresting and practically valueless drill. He wants to see some reason for doing things, and results count. The lack of more vital subject-matter in the seventh and eighth grades undoubtedly accounts, in part at least, for the large numbers of pupils never seeing the inside of a high school building. A child at this age is curious and has a desire to exercise judgment. A period of exploration and self-discovery is being passed through. The boy wants to do things for which he can see need and from which he can expect to get results. He cannot be expected to find himself in monotonous and endless reviewing of subject-matter which does not appeal to him. He is a new being and he demands new fields and new opportunities. Is it any wonder that he wants to get into the active world outside? He almost deserves to be congratulated. The wonder is that so many survive.

We are gradually coming to realize that the end of the sixth grade marks a natural psychological division in the life of the child. Surely we shall not fail to realize also that this is an opportune time for the introduction of subjects which are new and full of meaning. As we have already said, the boy is a *new* boy; the girl is a *new* girl. Old things have passed away and new wants and new desires manifest themselves. The senses are active and alert and many natural instincts are prominent at this period. Many a student would find satisfaction and profit in the study of general science in this unusual period of his life. In many instances such study would furnish a new incentive for continuing in school. If we are to educate the student so that he can play the game of life successfully, then surely at this period when his whole being is so responsive, we ought to give him an opportunity

to learn the rules of the game, which, as some one expressed it, are only the "laws of nature." By beginning science in the seventh grade, we would not only enrich this grade but we could relieve the regular high school program also. This would afford an opportunity for the student to take some extra high school courses for which he otherwise does not find time in the four years of high school work.

My plea for science in the seventh and eighth grades is not made for the average students only. Many of these have survived in the past in spite of what we offered them. But how about the poor "unfortunate misfit" to whom an Irish schoolmaster in a Pennsylvania school district once said, "What God Almighty has not given you, I cannot give you. Take your books and go home." Should the student be sent home because he is not bookminded or because he does not readily accept what we have to offer him? Has he no right to something in which he is interested? If my own experience with boys studying general science in the ninth grade has taught me anything, it is that general science would be the salvation of many a boy in the seventh grade, were it offered him. There are many more like the "dullest boy in school" who, while playing along the roadside, with bugs, was found by his teacher. A little questioning on the part of his sensible teacher revealed the fact that the boy had an intense interest in bugs. She encouraged him, gave him some books to read and later he became a specialist in this line. Should this boy have been allowed to leave school because he could not learn arithmetic or because he could not spell or learn technical grammar? Is this an exaggerated instance? I think not. Did not Edison's teachers feel sorry for his parents? Was not George Westinghouse a problem because he persisted in playing truant and was he not often found around railroad yards? I know of a successful science teacher whose interest in science began when as a dirty, ragged urchin he accidently happened into a room where the falling of a penny and a feather in a vacuum was being demonstrated. According to his own testimony, that one thing made him want "to know more."

It does not seem reasonable that at a time when scarcely a line of human endeavor has not been completely revolutionized within a half of an ordinary lifetime, that we ought to be unable to hold our students in school and interest them in science study. Yet

such is the case. General science, we are told, came into the high school, largely as a result of the failure of the high school to get hold of its students for special science study. We have been plunging our students into special sciences for a few months and then wondered why they do not like it or why they learn so little science. We begin many other subjects when the pupils enter school and continue them through the grades and not infrequently into the high school, yet the subject which has to do with every phase of human activity at all times, we insist on giving the student in one or two years but only after the proper time for the beginning for such study has gone by. The junior high school presents a new opportunity for instruction in general science so that whether a student continues in school or not he may at least have a commonsense idea of the things about him. According to the testimony of many students, they leave school because they are not interested in what the school has to offer them. According to Mr. Ayres in his study of "Laggards in our Schools", retardation and elimination occur most often after twelve years of age when pupils are required to take up a "continuation of a wearyingly monotonous curriculum." If a student fails in a subject we say he is guilty of all and make him take the whole curriculum over again. The old Jewish Law had nothing on us when we consider this matter. Here is an opportunity to offer the student something different and general science because of its very nature has interest for the boy and girl at this period.

We assumed at the beginning of this discussion that the six-three-three plan of school was to be adopted. Whether or not this grouping of grades takes place, I believe general science should be begun in the seventh grade and offered in the eighth and possibly the ninth.

What shall be the nature of the general science course in the junior high school? First of all the course should be really *general* science. We have already insisted too much on the purity of science in the other science courses. Whether we will or no, we must face the fact that as a rule we are failing to hold students in school and according to the report of the Commissioner of Education for 1911, while most of the subjects were gaining or at least holding their own, the sciences were actually losing in numbers. This condition may be somewhat improved now but it is far from

satisfactory. According to Professor Barber, much of the distaste for science is due to our trying to put our research methods of pure science to work with the adolescent or the high school student. Surely if we have a lack of interest in science when every artery of the whole realm of our existence is pervaded by its application, so that our very mode of life is entirely changed, we are failing to make our students realize the value of science. Those who oppose general science on the grounds that it is not scientific knowledge, should tell us what is wrong with the special sciences that they are considered by so many of our students as something to be taken only as a last resort. The adolescent child needs information along the whole field of science. He is living in a world in which he is constantly observing phenomena which need to be explained to him if he is to live properly. These explanations do not require any one special science—they include them all. General science should be inspirational and should give an appreciation of the whole field and bring as much as possible into the experience of the everyday life of the student. We do not teach geography in order to turn out explorers, nor history to make historians and we should cease trying to teach science as though we expect every child who studies science to become either a physicist, a chemist or a botanist. The practical human side is infinitely more important than the specialist's side at this period. Does the average student who is given a quantitative experiment in chemistry even in the last year of his high school career become more scientific and will this scientific attitude carry over to the time when the school days have come to a close? We dare say, usually not. The problems of the active adolescent boy and girl are not problems of physics or chemistry or botany or any of the other special sciences. They are problems dealing with actual life and for the solution of these problems we cannot and certainly need not try to separate the sciences.

We should not as some suggest, retain in general science only what can be adapted at once to the life and experience of the child. The experience of the child may be used for a starting point; it should certainly not be made the end. There are many things we can enjoy after we know more about them and this means a wider knowledge and consequently a broader education. For example, we could hardly say that a study of some elementary astronomy could

be immediately or perhaps ever adapted directly in the life of the child but the subject is wonderful for developing interest and imaginative power. By all means we should give the child at this period a look into the great universe. He will never fail to become interested. General science is called by Dr. Caldwell, an "opportunity study." We may consider this opportunity as one for giving students who will never study pure science, an intelligent understanding of the common affairs of life and also as an opportunity to lead pupils into new fields of interest. If the course is made up of such subject-matter as shall take into account primarily the pupil, the course will undoubtedly be best for the science work which is to follow.

If we are to have science work in both the seventh and the eighth grades, what shall be offered in the seventh and what in the eighth? It is interesting to note that most writers on general science topics do not commit themselves on this point. It is evident that there is not general agreement among those who have tried to tell us what the basis should be. Some contend it should be primarily along biological lines first and the other sciences should be the basis later. Others take the opposite view. The facts are, there seems to be little more in favor of one than of the other. Both have been used with excellent results and as we have already stated, the work must be made general. There is no longer any ground for the contention that simple physics cannot be taught in the grades. The simple laws and principles of physics in the explanation of various phenomena, have been effectively used in various places as low as the sixth grade. We have in many schools physiography and physiology in these grades. Students of the high school and of the grades, tell us that these subjects are poorly taught, are losing ground and are really not justifiable courses in the grades. There seems to be no good reason why the fundamentals of physiography should not be taught in a good general science course. I have found a study of the air a very good starting point for general science in the ninth grade and this might as well be made a beginning topic in the seventh grade. I do not believe the subject of physiology, as usually taught, has any place in the junior high school. It is not desirable at this period to have the attention of the child called so much to the organs of his own body and the study of physiology rightly belongs in the upper grades of the

high school after he has studied botany, zoology, physics and chemistry. This does not mean we are not to study hygiene. The junior high school course in general science should be made strong in practical hygiene study. Some elementary bacteriology should be introduced early in the course in order to get the child aware of the causes of many diseases and of ways to prevent them. My experience has been that students are readily interested in the subject of bacteriology. First of all, of course, the child must be made to see the problems of hygiene and then the study will not only become interesting but very practical. A study of the sanitary conditions under which food is obtained always affords lively interest. In the study of the air, we have problems of hygiene such as, ventilation of home and school buildings and also of the dust content of the air with special reference to the live dust. Cultures of air bacteria and molds should be made. In the study of water, local conditions with reference to the purity of the water will constitute a problem along sanitary lines. Here methods for purification of water should be demonstrated and we have elementary physics but in terms of a practical social problem so as to enable the pupil to live more efficiently. The study of both air and water may be made the basis for certain lines of physical geography.

As nature study work, we can do no better than to acquaint the student with his friends in the animal, plant and insect world and of methods for protecting those which are friends. The pupil should learn to distinguish between useful and harmful birds and plants; also the ways to rid ourselves of our enemy pests in the plant, animal and insect world. Good examples are the rat and the detestable house-fly. What better opportunity could one want for again teaching hygiene! How is the house-fly harmful? Does he carry germs on his body? An agar culture will impress this on the student in such a way that he will have some incentive from the standpoint of health for fighting the fly.

General science should include considerable plant study. Why not introduce the child to the elementary principles of agriculture through the garden which is of such importance at the present time. The girl who said to me, "I am going to put some of these things we are learning into practice in my garden this summer" was getting science which was helping her to live better. The locality and the experience of the teacher will determine largely what the material to be used shall be and what the problems which

will arise. General science can be made to include physiography, hygiene, botany, zoology, physics and some chemistry. These should be used whenever needed to help the child to solve his problem whatever that may be. His environment needs to be interpreted and and his experience broadened and the wise teacher will find the subject matter of general science adapted for interpretation.

Having determined what our subject-matter shall be, what shall be the method of presentation? It is almost useless to say the work must be simply presented and must not be too abstract or technical. As in the case of the subject-matter, perhaps the aim of general science will help to determine to some extent the method to be used in presentation. Shall it be for preparation for future courses in science? Personally I believe not and I have tried to teach the subject as Professor Elhuff expressed it when some one asked him how he would teach general science in order to prepare the student for the subsequent courses in science. His reply was, "Teach general science as though the student never intended to take a more advanced course in anything. In other words, teach him how to live." Professor Coulter expressed the same thought when he said there is no need for giving any particular aim for general science. According to his view we are just to let general science do its part in the development of the child and broadening his experience which means real education and then there will be no need to be concerned about the subjects which are to follow.

There has been objection to general science teaching because, it is claimed, we are not teaching real science. I believe a scientific attitude of mind is important, but this, as some one expressed it, is only "trained common sense," and a practical social issue explained through the use of the special sciences just as they are needed, surely is a training of common sense and therefore a development of the scientific attitude. The spirit of inquiry is developed in the boy as he learns to explain his problems and as he gets a better understanding of his surroundings as a result of his study. Professor Tait says, "science aims at giving a common sense view of the world in which we live." "Method" says Professor Dewey, "means a way to a result, a means to an end, a path to a goal." He further suggests that general science has its justification in the "attempt to get nearer to the world in which the student lives and

away from he world which exists only for the scientist." Professor Judd, in his book "Psychology of High School Subjects" says, "the chief business of science is to train the student to see problems." He further adds, "We must find the means of arousing in the student the problem-seeking and problem-solving attitude. We cannot depend on ordinary life to cultivate either of these attitudes." He further says, "We must find devices which will arouse the problem-seeking attitude and we must then focus this attitude upon commonplace surroundings." If these men have the correct view, then it remains for us to find a way for teaching general science so as to make the student see problems; of making science fit into his world; and of explaining problems which the student encounters, by the aid of science, thus giving him a common sense view and an intelligent understanding of his surroundings.

How is this to be accomplished? There are those who contend that we must always begin with things with which the student is familiar and teach only what can be applied at once in the life of the student. But does the student or even the average adult see problems in everyday life? Usually he sees them only after they have been pointed out to him. Professor Judd says, "the unfamiliar presents obvious problems." He points out however, that we must not expect the unfamiliar to furnish us all our problems. The facts are that there are many unfamiliar and often mysterious phenomena connected with everyday life and it remains for the teacher to make the student see the problems and to make him want to find a solution. Not infrequently, too, the familiar and mysterious at first can be interpreted in the simplest experiences of the student. Certainly we should not, as has already been stated, limit our general science to what is already common to the student nor to what can be immediately used in the life of the student. We must lead him into new fields in order to broaden his interests. In this way general science can be made a factor in the life of the student in helping him to see his problem and to solve it in keeping up and broadening his experiences and interests; and in leading him into new fields of activity some of which may have a special charm for him.

The so-called project method seems to be especially suited for this purpose. The term project has been given various meanings when applied to teaching. It has been used when referring to a simple

experiment which would perhaps not require a half minute to perform and again it has been used to apply to six-months work in some general field. The facts are that most things we do are projects and whatever differences of meaning may have been given to this term as a teaching unit, there is somewhat general agreement that it means something fairly definite to be done or in other words that project-teaching is problem-teaching. A project has been generally defined as "an undertaking of comparatively limited scope, in which a pupil or a group of pupils or an entire class under the direction of a teacher, do some definite work in actually making something or in observing or interpreting some phenomena or process." A project then may mean the construction of something, the growing of some crop or animals or it may merely mean the finding out or understanding the reason for certain phenomena. A need or a desire for finding out or doing should be the basis and so far as possible should be done by the student. This method puts purpose into teaching and it will be remembered that lack of purpose is one of the main charges against the work of the seventh and eighth grades as it has been in the past. If the problem has been fairly grasped by the student he begins to inquire—to try to find out something about it. The fact that he wants or needs to know becomes an incentive for his study. He draws from every available source and here we have an example of how impossible it is to differentiate the special sciences for this purpose.

As stated before, the project should originate so far as possible with the student but he must not be expected always to find problems without assistance. A lecture or a demonstration by the teacher, a conversation between teacher and student or something read or observed by the student may at any time produce a problem which may best be developed as a project. No teacher of general science should attempt to follow such a set schedule that he cannot at any time change his plans so as to help solve a problem even should such solution require days or in rare cases even weeks to solve. Why should we conform to a set schedule? It is better, far better that the student be given help when he needs help in the solution of a practical problem. There may be times when a whole class could profitably carry out a project—at other times groups of students may work on different projects and occasionally some students may work individually. In every case the class through dis-

cussion, should get the benefit from whatever has been done. Taking care of the school grounds might well develop into a class project. Suppose some student asks, "Why does the wind blow and what is wind anyway?" Instead of an answer in a few words, which does not really mean anything to the student, a study of the air, with particular reference to convection as a result of temperature and pressure, may be made. Not only will the answer to the boy's question finally be effective, but the principle of the wind systems of the whole world can be developed and understood. With some simple demonstrations such as showing the expansion of the air when heated and convection in air and in water the student can also effectively be taught some principles of physiography. There will then no longer be the disconnected bits of knowledge regarding winds and other weather phenomena, but general relationship which will have meaning and be much more readily understood.

In order to get new projects, it may prove very helpful and suggestive at the proper time to give the students an opportunity to make known something about which they want to know more. If this is done in writing, the teacher can at least have a basis for further projects and can guide particular students along the lines they have indicated or lead them into other fields if in his judgment the one selected is not wise. Another method the teacher may use occasionally is to put before the student a list of suggested experiments and let them select from the whole, the ones which appeal to them most. Here again the teacher can select the ones which seem to appeal to the larger portion of the class. It is evident that the teacher must exercise tact and judgment if this method of selection is to be successful.

No list of projects should by any means be made and then slavishly followed nor would the list which might be used in one school be applicable as a whole to another school. Following is a partial list of projects, some of which would be adapted for any school in any locality:

Raising of some crop on a plot.
Raising of stock.
Construction of some sort (concrete walk, post, etc.)
Making of furniture.
Planting trees, shrubs, flowers, etc.

Study of fireless cooker and perhaps making one.
Production of sanitary milk.
Water supply.
Baking bread.
Canning fruit.
Testing seed for neighboring farmers.
Making pictures, lantern slides for class use, etc.
Principle of refrigeration.
Principle of the steam engine. (for boys.)
Operation of the telegraph.
Wireless telegraphy.
Why a stove "draws."
Study of different fuels.
Why water puts out a fire.
Distillation of wood.
Purification of water, (different methods.)
Why food cooks so slowly at high altitudes (cook some potatoes under increased pressure and under reduced pressure).
Testing for per cent of butter-fat.
Principle of the siphon.

Manifestly, this list might be made much longer but this is not intended as a complete list but merely as a suggestion as to the possibilities along the line of project teaching. While this method offers such possibilities that it seems we can hardly be too optimistic about it, yet a word of caution is perhaps in order. No method would result in a more miserable failure than the project method unless used skillfully. It is evident at once that a teacher must be energetic, tactful and resourceful. Unless already familiar with this method of instruction in science no teacher ought to plunge headlong into it. A much wiser course to pursue is to take it up gradually. Many things in science can be and in fact should be, taught as just disconnected information to be used whenever needed. With subject matter well chosen and good judgment exercised on the part of the teacher this method can soon be used effectively with the adolescent boy and girl who are so anxious to get results from what they do.

General science in the junior high school is not to be considered a cure-all nor as a prevent-all. In the reorganization of our program of studies for the student of this period we are endeavoring

to give the student something which will appeal to him and which will make him see some reason for continuing his work in the high school. General science in its manifold phases has in it something which appeals to almost any and every student if he can be properly led to see that it means that he will be better able to solve his life problems if he has a knowledge of the things about him. If we are to judge at all from what has already been accomplished by general science in the ninth grade we have every reason to believe that if the subject matter is properly organized and properly presented, the seventh and eighth grade students can be greatly benefited whether they continue in school or drop out at the end of the ninth grade and I believe general science offers an incentive for more than one boy to continue his studies.

Some Objections to Project Teaching.

W. N. Clute, Joliet, Illinois.

Notwithstanding the enthusiasm manifested for the project method of teaching general science, there seems warrant for entering a few words of protest and caution concerning it. The project seems to be simply a method of procedure—a thread upon which various experiments and investigations may be strung. From the nature of the project these things are often totally unrelated to one another except for the thread that holds them together. In one such project recently suggested in a journal for teachers, I note references to radiation, conduction, combustion, insolation, manufacturing processes, commerce, agriculture, zoology, botany, biography, bleaching, dyeing, acids, alkalies, soaps and the compound microscope. If this is a fair sample of the project method, those critical first year science teachers who insist that general science is a "hodge podge" are not far out of the way. Nearly all the items in the list are excellent subjects for study but not in the purely fortuitous order in which any project arranges them.

What the student of general science needs first of all is a thorough grounding in general scientific principles. With such a foundation it is possible to build up a superstructure of the special sciences, singly or in combination. At this stage, the project is

not only permissible but actually desirable since it tests the pupil's knowledge in many fields and demonstrates his ability to use such knowledge in solving the new problems that arise in every day life. To adopt the project method earlier, is to reverse logical procedure by requiring the pupil to study results and completed processes before he has any adequate conception of the causes. The pupil must be taught to creep before he can walk, much less fly.

A second objection to the project method is that it leads to talk about things rather than to a study of the things themselves. It necessarily calls for much consultation of reference books with a further increase of the child's store of second-hand and hear-say information. I do not mean to depreciate the use of reference works, but I question whether a child of twelve is as well employed in digging scientific knowledge out of a book as he is in studying some scientific problem or principle at first hand. The project method, also, is likely to result in much ineffectual talk and useless dialogue, taking time that might be more profitably devoted to something else. If general science is ever to be, as its friends claim for it, an introduction to the special sciences, it must adopt the laboratory method and bring the child into contact with actual things. In no other way can we develop in our people that originality and independence of thought and action so necessary to continue this a progressive nation. The child as he comes to the high school, is altogether too dependent upon books. We must encourage our instructors in science to get away from the lesson-hearing, tell-it-to-me, watch-and-see-me-do-it phase of teaching and adopt the problem solving method. In general science, especially, the student is better employed in studying scientific principles and finding their applications in various phases of existence about him than he is in trying to discover and understand the principles involved in some complex subject.

A friend of the project method of teaching recently advocated it because, among other things, it "seldom ends in a complete, final or absolutely finished conclusion." This, however, appears to be the very best reason for objecting to it. If the study of science is not concerned with facts and does not result in very definite conclusions, it is scarcely entitled to the name. Even to call it general science does not warrant us in being satisfied with general conclusions.

How the Experience of Physical Geography may be an Aid to General Science.

R. H. Whitbeck, University of Wisconsin, Madison.

It may be helpful to the friends of general science to review the experience of physical geography as a high school science during the last twenty-five years. The most famous educational report that has been presented in this country was the report of the Committee of Ten of the National Education Association. This report appeared in the early nineties, and has been regarded as the most epoch-making document on education during the present generation. We are now hearing a great deal about the reorganization of the school curriculum. The report of the Committee of Ten, twenty-five years ago, was intended to accomplish precisely the same thing, namely, a reorganization and improvement of education in elementary and secondary schools. The most eminent and competent educators of the United States served upon the various sub-committees.

PHYSICAL GEOGRAPHY MADE THE INTRODUCTORY HIGH SCHOOL SCIENCE.

The significant thing for our present purposes is that by practically unanimous consent the Committee of Ten recommended physical geography as the one preferred science above all others for the first year of the high school course.

This committee drafted four standard courses of study, namely, classical, Latin-scientific, modern languages, and English courses. In every one of these courses, geography was recommended as a required study, sharing this preference with English, algebra, and history. The general committee had no particular interest in any one science above another, but as the result of their many conferences they selected physical geography as being best fitted of all the sciences for the introductory science of the high school. This endorsement by such an eminent body of educators started physical geography off with most excellent support. Very shortly, text-books of a more scientific type than their predecessors appeared and physical geography was rapidly introduced into nearly all high schools, being offered as a rule in the first year.

Those who favored physical geography thought mainly of its content when they chose it for the introductory high school science. They knew that the study dealt with our immediate environment, the air, the earth, and the water. A large portion of the phenomena studied are open to easy observation. Weather and climate can be studied anywhere. Almost every locality furnishes opportunity for studying the process of weathering and erosion. Stream work, soil formation, lake shore or seashore erosion and deposition, springs, ground water, and many other natural phenomena may be seen in almost any locality. Expensive microscopes or other apparatus were not required. The great laboratory of nature lay around the school building. Quite naturally the Committee of Ten and school men generally thought physical geography an ideal first year science for the high school.

A few years after the appearance of the report of the Committee of Ten, twenty-five per cent of all high school students in the United States were reported to be studying physical geography. This means that during the four years of high school almost all of the students in the high schools of United States studied this branch. With such high educational endorsement as the study had received, and with such a cordial reception from the school men, it would seem that physical geography should have proved successful. Yet to-day we find that scarcely one-half as high a proportion of high school students are studying physical geography as were studying it twenty-five years ago.

DECLINE IN HIGH SCHOOL SCIENCE MORE APPARENT THAN REAL.

Of course, it may be pointed out that all of the sciences have *seemingly* lost ground during this quarter century. As a matter of fact, I do not think they have lost ground to anything like the extent that the statistics would seem to indicate, if we do not look below the surface. It must be remembered that twenty-five years ago a science was usually studied for one-third or one-half of a year. The old series known as Steele's Fourteen Weeks in Chemistry, in Botany, in Zoology, and in other sciences were among the most widely used text-books. These were superseded by Steele's Popular Series of science books, but these also were designed for a single term of school, sometimes a third of a year, sometimes a half, but never a whole year. Now it is customary to carry physics, chemistry, and biology throughout an entire year. Twenty-five years ago a student might take botany the first term of a school

year, physics, the second term, and chemistry the third term, all within one year, while under present conditions he would probably pursue one science throughout a year. Plainly, then, we can not compare the reports regarding the number of students electing science studies now with the reports of those earlier years; and if it is discovered that seemingly there were more enrollments in science studies in the nineties than there are now, we must look behind the figures and ascertain how long the students of the earlier years pursued each of these sciences. This, however, is merely a digression intended to caution those who are unduly pessimistic about the declining popularity of science studies in the high schools. Probably sciences have not gained in popularity during these years but I am sure they have not lost in popularity so much as the reports of the Commissioner of Education might lead us to believe.

WHY PHYSICAL GEOGRAPHY PROVED DISAPPOINTING.

However, it is clear that physical geography has not met with the success that its friends of the nineties anticipated, and because it has not proved to be so satisfactory as an introductory science as was expected, there is now under way an active movement to substitute some other science as the introductory one. The science which is most in favor is usually called General Science, First-year Science, or Introductory Science. This study has received most vigorous and enthusiastic support from many sources and has been, or is being widely introduced into the schools of the country. Also it has met with some vigorous opposition, although the support has apparently been much stronger than the opposition.

It is not intended in this paper either to oppose or to support general science but rather to point out a lesson which may be gathered from the experience of physical geography. The committee that unanimously recommended physical geography as the required science in the first year in all the standard courses were thinking mainly of the fitness of the subject itself. They did not realize then as we do now that there were practically no teachers in the country who had been trained to teach physical geography according to modern ideals. This branch can not be successfully taught unless a considerable amount of field work is done and is made a regular part of the course. If made strictly a text-book and in-door study it has lost more than half of its potential value.

Doubtless the supporters of physical geography believed that if a demand for teachers existed, the normal schools and colleges would prepare the teachers. But, as a matter of fact, this was not done. Most normal schools can not be expected to do very much toward training science teachers for the high school because their function is primarily to train teachers for the elementary schools, and in those schools very little science is taught.

Only a comparatively small number of colleges offered instruction in physical geography until the last fifteen years and those colleges could train only a small fraction of the physical geography teachers demanded. The out-of-door work which is so essential to the success of physical geography was not undertaken in any large degree, partly because there are many difficulties in the way of doing it, and still more, because very few teachers felt themselves justified in taking classes into the field to study things which they themselves did not understand. The inevitable result was that physical geography was made almost solely a book study and a memory study, and failed in a large degree to give the scientific training which was intended.

Little by little this failure was recognized by the school principals and superintendents. They saw that physical geography was being taught in a mediocre way, mostly by teachers who had not been trained in the subject. If they sought trained teachers they found them hard to secure, but, as a rule, they did not seek them. Commonly the physical geography classes were assigned to the new teacher who had a vacant period. I have visited schools where the music teacher was conducting the class in physical geography; in another, where the stenography teacher was doing it, and frequently where teachers of English, history, or Latin were doing it; and practically every one of these teachers admitted that she (or he) had had no preparation for the work and therefore, would not profess to be competent; she usually regarded her teaching of the subject as a make-shift soon to be remedied. The situation was usually remedied by taking the next new teacher who came into the school, and who was equally unprepared. Correspondence with school-men in nearly all parts of the country leads me to believe that this has been the practice almost everywhere. I have visited scores of schools in Wisconsin and outside and have only occasionally found physical geography taught by a teacher who had made

anything like an adequate preparation for the work. Under such conditions, success is impossible, and physical geography, after a quarter century of trial is now on the defensive and in many schools is being replaced by general science, agriculture, or some other branch.

THE OPPORTUNITY AND THE PROBLEM OF GENERAL SCIENCE.

Just now general science is being given its trial. Everyone of us who are interested in science teaching wishes general science to yield its highest possible educational returns. Whatever science is taught in the high schools, we want it to be well taught and we want it to win support. It is particularly important that the introductory science shall be well taught, for one of its purposes is to inspire students to continue on in scientific studies. General science is valuable more for the appetite which it creates than for that which it satisfies. Its greatest function will be to open the pupil's mind to the world of science and to make him hungry for more. How can this be accomplished? Surely not by the procedure which was employed in the case of physical geography, entrusting its teaching to the young, untried, untrained teacher. General science will prove a disappointment, unless school principals employ competent teachers. A teacher ought to have a very broad preparation involving some knowledge of nearly all of the recognized departments of science. The universities do not at present encourage their students to take more than about two branches of science. The tendency of university instruction is to concentrate upon one major and about one minor line of study. This plan tends to make physics teachers or biology teachers or geology teachers, but only in an imperfect way does it tend to make general science teachers. In a large gathering of science teachers of Chicago a year or two ago this question was asked of one of the leading advocates of general science in this country:

"What do you consider an adequate preparation for a teacher of general science?"

The answer was, as I recall, "I should wish a teacher of general science to have had in a good university, at least the following: a course in physics, in chemistry, in botany, in zoology, in physiography, in bacteriology, in physiology, in astronomy, and in mineralogy. Surely we will all agree that we should like to have general science teachers thus broadly equipped, but where are such teachers

to be found. Where shall we find teachers in any considerable numbers who have had one-half of this preparation? The fact is that nowhere are teachers in large numbers being prepared for general science teaching, and the result is that in scarcely one half of the schools where general scinece is taught is it in the hands of a person who considers himself or herself prepared to do the work. Enthusiasm will accomplish a great deal. General science is in itself interesting, and even with fair teaching, may succeed quite satisfactorily. Most of the general science classes that I have visited were thoroughly enjoying their work and many of the teachers, though inadequately prepared, were putting a degree of enthusiasm into their work which carried it along and won quite creditable results. Nevertheless, it is true that in many quarters the expectations entertained with reference to general science are not being realized. I have at hand some forty letters from teachers in one of the states where general science has been tried for five or six years, and the general tone of the letters is one of disappointment. There is danger that general science will repeat the history of physical geography unless school men shall demand of the schools that train their teachers an adequate preparation for science teaching. If the principals will insistently demand that the training schools and colleges train teachers for general science, that demand will be in part met.

THE NEED OF QUALIFIED TEACHERS.

The course before the friends of general science now is less to enlist support for the study in the high schools than to secure the training of teachers to handle the study. If this is accomplished, general science may escape the experience of physical geography and may prove worthy of the confidence which thousands of school men are now placing in it. But without competent teachers no branch of study can permanently succeed. In the competition for time between the various studies in the high schools the weaker branches will be crowded out. As I see the problem, there are two important steps to be taken in the field of general science; first, a closer approach to a standard course, that is, a better agreement as to what constitutes general science; and, secondly, a concerted, nation-wide effort to secure teachers trained to handle the study. Neither of these is a step easy to accomplish but much can be done toward its accomplishment if a vigorous effort is made.

Student Interest in Subject Matter.

Harold Lyon, High School, Medford, Massachusetts.

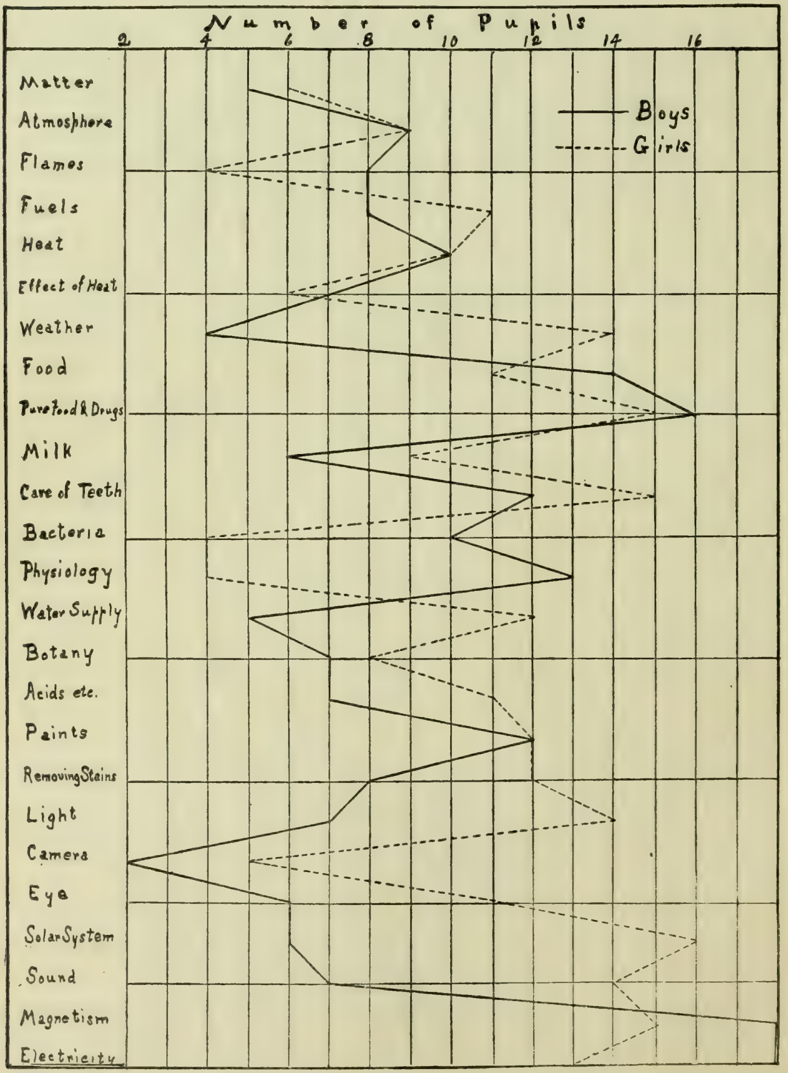
In reading many of the recent books published on the subject of general science I find that there seems to be little or no agreement among the various authors, on just what subjects should be considered in such a course. Last year I tried to find out the pupils' opinions of some of these different subjects and submit the results thinking that they may be of interest to other teachers.

Some authors present the subject from their point of view, for example, one whose interest is mainly physics, emphasizes the physical standpoint throughout his book. The more recent authors, I think have presented the subject from two view points, which in my opinion is the correct one. First from the child's point of view, presenting facts that are of interest to the child and secondly to make them as practicable and as valuable as possible. Something that the child can take home with him and make use of.

Many special science teachers complain that the courses given in general science are giving the child some facts that they themselves want to use and which rightly belongs to their respective subjects. On the other hand there are those science teachers who complain because the pupils after taking a course in general science, come to them, without the slightest knowledge of the science principles involved. I cannot agree with these latter teachers. In my opinion general science should not be a stepstone to any other science but should be complete in itself and so arranged that it would not interfere with any other subject. General science does stimulate further interest. Out of my classes which numbered 93 at the start, 32 disappeared and I ended the year with 61. I found that only 23 of these were to take further work in science, 18 in physics and 5 in chemistry. How this compares with a class never having taken general science and of the same size would be interesting to know. I am inclined to think that it would be the same.

I think that general science is primarily for those that drop out of high school before finishing the four years, or those who do finish

and do not take any other science. I know that the 23 in my classes who are to take further work in science would certainly have chosen physics or chemistry if they had never taken general science. In my classes there are 49.2 per cent girls and 50.8 per cent boys.



It occurred to me that it might be of interest to find out what subjects presented during the year were of greatest interest and how boys and girls agreed on the same subjects. I made out a list including all subjects touched upon and asked them to check those which interested them. The subjects are below and are really subject headings. They must not be taken literally for as much as possible was taken up under each heading.

In touching upon these subjects (see chart) I made them as brief as possible covering everything of interest and trespassing on no one's territory. In plotting the results I find some very interesting differences of opinion among the boys and girls. Matter and atmosphere were of about equal interest. Flames brought the girls behind the boys. With fuels, the girls go ahead of the boys and heat brings them together again. Curiously the effect of heat showed a drop for both. Fourteen girls were interested in the weather to four boys. The question of foods brought both somewhat nearer but the boys going ahead of the girls. Pure foods and drugs seemed very popular to both and both showed a moderate interest in the milk question. Teeth and the care of them brought both up again with the girls ahead of the boys. Bacteria and hygiene appealed strongly to the boys but strangely to me they dropped below the girls in the study of the water supply. Botany seemed to be of equal interest, while chemistry appealed much more to the boys than the girls. Removing stains naturally held the girls above the boys. The camera brought both down again with the girls the more interested. The human eye brought the interest up a little with the girls in the lead. The sun and the solar system showed the girls in favor. Sound brought the boys up and the girls down. In magnetism and electricity the boys are naturally ahead of the girls and they still remain there in the subject of physiology.

In the chart the figures at the top represent the number of pupils signifying an interest in the subjects which are listed at the side. Some pupils of course only showed interest in one or two subjects, some none at all, while others seemed to find something interesting in most all of them.

The First Year—For the Eighth Grade—of a Two Year Science Course for the Junior High School.

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GRAND RAPIDS, MICH.

This article is the result of work pursued in a course in the organization of science in the high school. It was suggested that it might be of sufficient interest to people in education to warrant its being published. Part of the material in this outline has been worked out in regular class work, and part of it has been prepared for future use. Part of it, therefore, has been organized from the practical standpoint, and part from the theoretical. It is now what seems to be the best outline for work in the particular schools in which I am teaching. The sub-topics "projects" and "problems" have been selected from various text books, outlines, and my own work.

This course is being prepared for the eighth grade of a junior high school, that I think is fairly representative of the general conception of such a school. It occupies a large building by itself, and is made up of the seventh, eighth, and ninth grades.

Although I have been in the city of Grand Rapids, several times, I am not as well acquainted with the community in which this school is located and the home life of the pupils of the school as I should like to be before outlining a course of study such as this; for I firmly believe that the organization of a science course should first of all consider the home environment of the pupil for whom it is intended, and then see that the topics covered by projects, problems, experiments and observations are more or less closely related to his common or life experience.

I think all the work should be organized around a few large, outstanding, unifying topics. General science has been called a hodge-podge because it dealt with such a variety of fields of knowledge, and has also been called illogical. As a rebuttal to the latter point, Parker, in "Methods of Teaching in High Schools" points out that

if the pupil keeps the problem in mind—regardless of the field from which it was taken—searches for evidence, evaluates it carefully, rejects the irrelevant, applies the relevent, and formulates his conclusions and verifies them, he is being logical in the highest sense. General science does truly try to break away from the highly organized, logically arranged subject matter that is the result of the working of an adult mind, and which only an adult mind could be expected, with continuity of interest, to follow. It strives to psychologize the material studied, adapting the selection and presentation of work to be covered to the age and capacity of the pupils for whom intended. But even though we keep these thoughts in mind the greatest benefit will result by having the problems clearly related to some large unifying topic, which will serve as a justification or aim or motive for dealing with them.

Although I have never had the privilege of doing so, I think the best way to teach general science is without having the pupils all own the same kind of a text book. The course should be carefully organized and outlined. There ought to be a library of different science text books, books on scientific information, biography of scientists, scientific magazines and periodicals, with a laboratory equipped with suitable chairs, tables, and simple apparatus, and for the projects to be worked out from these—it seems to me this would be the best way to teach the subject.

But as it will be impossible to secure many of these conditions immediately in this school, it will be necessary to choose a text book which will ensure a source of information and reference to every pupil. A text will be used that will be fairly adaptable to the conditions of the school.

It has been decided that in the eighth grade there shall be three recitation periods per week, required of all pupils.

Due to lack of room at the present time for doing otherwise, the experiments will be largely demonstrational. After the beginning of the term and the pupils have become somewhat accustomed to the manner of doing, groups of pupils may be asked to do for the class the demonstration experiments they are capable of doing.

Pupils will often be asked whether they try to perform experiments for themselves at home, or to make use of facts and knowledge gained in the course.

In this school the shop work for boys and domestic science work for girls is well provided for, and many opportunities will be seen

and used to correlate the work in general science with that in those subjects.

There will also be points of contact with arithmetic, geography, history, and physiology which will be utilized to vitalize both the science and the other subject.

The pupil will be required to keep a record of the experiments and observations. These will not be of the old type of formal, exact, hate for science producing type. The pupil will be allowed considerable freedom as to the manner in which he makes an honest, true, record or statement of the work done as experiment, assignment or observation.

Without doubt, it will not be possible to cover all the work here outlined in the year of work in the eighth grade. The things that will determine what parts shall be covered and which left, will be the probability as to which topics will be of greatest benefit to the greatest number of pupils required to take the science in the eighth grade, and the probability as to which ones had better be left for a more complete treatment in the elective course that is to follow this one in the ninth grade.

Topic 1. Combustion.

Sources of heat.
Kinds of fuels.
Project: Making a bonfire.
- List of questions about bonfire.
- Why the fire burns.
- Lesson on elementary chemistry.
  - Elements and compounds.
- What becomes of wood when burned.

Oxidation.
- Why stones not used for fuel.
- Heat produced by oxidation.

Project: Making a thermometer.
- Effects of heating.
  - Water heats slowly.

Project: Thermostat.
- How heat travels.
- Ways for heating a home.
- How science room is heated.

Project: Study of a chimney.

What smoke is.
How these things were formed.
How illuminating gas is made.
Properties of illuminating gas.
How gas is made in Grand Rapids.
Study of candle flame.
Study of Bunsen burner.
Carbon dioxide.
How produced.
Body fires—relation to physiology.
Control of fires.
Losses from fires.
How to prevent them.

TOPIC 2. WATER AND ITS USES.

Three forms.
Changes from one to another.
Relation of heat to these changes.
Changing water to steam.
Evaporation.
Ice machines.
Changing vapor to water.
Condensation.
Dew, rain, frost, snow.
Distillation and applications.
Transpiration.
Influence of bodies of water on climate.
Relation to geography.
Fruitbelt of Michigan.
Composition.
Analysis.
Synthesis.
Water supply and sewerage disposal in Grand Rapids.
Source of water.
Impurities.
Filtration.
Health conditions before and after filtration.
Water system.
Sewers.
Various methods for disposal.
The one used in Grand Rapids.

Industrial uses of water.
- Water a solvent.
  - Relation of this to plant and animal life.
- Uses in industries.
  - Relation to geography.
- Mill ponds and dams.
- Water pressure.
  - Arithmetical problems.
    - Effect on construction and operation of submarines.

Topic 3. The Air and the Weather.

Does air occupy space?
Why kick foot ball farther inflated than empty?
Does air have weight?
- Meaning of weight.
  - Biography of Sir Isaac Newton.

Determine weight of air in class room.
Air pressure.
- Project: Common pump.
  - Meaning of pressure.
  - Problem: Barometer.
    - Biography of Galileo and Torricelli.
    - Story of making first barometer.

Distinction between weight and pressure.
Moisture in air.
- Effect on weight of air.
- Relation of temp. and amount of moisture in air.
- Dew point.
- Dew, frost, rain, snow.

Air pressure and winds.
High and Lows.
Weather map.
- What designed to show and how it shows them.
- How forecasts are made.

Rainfall.
- Map.
- Importance of rainfall.

Composition of air.
Impurities.

TOPIC 4. SOME FURTHER APPLICATIONS OF SCIENCE TO THE HOUSEHOLD.

Bacteria and food.
Clothes and how they protect us.
Household chemicals.
Bleaching, bluing, starching.
Dyes.
Baking powder and soda.
Yeast and fermentation.
Metals used in the home.
Oils, paints and varnishes.

TOPIC 5. LIGHT AND ITS BENEFITS.

Why thing are visible.
Intensity of illumination.
Measuring the light.
Reflection.
Refraction.
Color.
Photography.
Artificial lighting.
Benefits of light.

TOPIC 6. WORK AND ENERGY.

Meaning of work; of energy.
Work by running water.
What is a machine?
Classes of machines.
- Examples of each class.

Study of engines.
- Steam engine.
  - History of steam engine.
  - Biography of James Watt.
  - Story of steamboat.
  - Story of locomotive.
  - Steam turbine.
- Gasoline engines.

Relation of heat to mechanical energy.

TOPIC 7. MAGNETISM AND ELECTRICITY.

Frictional electricity.
A magnet.
Earth magnetism.
- The compass.

A battery.
  Kinds of batteries.
Current electricity.
  Heating effects.
    Household appliances.
Chemical effects. Electroplating.
Magnetic effects. Electromagnets. Electric bell. Telegraph.
  Motors.
Induced currents. Dynamo. Telephone.

TOPIC 8. NATURE'S BALANCE OF LIFE.

Meaning of term.
  Clover—rabbit—fox—wolf—man.
Overproduction.
  Potatoes.
Limiting conditions.
Why some forms stay, others do not.
Artificial selection.
  Biography of Charles Darwin.
  Good seed.
Germination.
Soil as source of plant food.
  Subtraction, and addition.
Why a plant needs water.
How water rises through the soil.
How liquid goes from cell to cell.
Food factories for all life.
  Leaf structure.
  Light and chlorophyll.
  The sun the Great Energizer.
    Relate to Topic 6.
Air for plants.
Public parks and city trees.
Birds, their food in relation to balance of life.
  Migration in relation to balance of life.
  Protection.
Plant fertilization.
  Structure of flower.
Seed distribution or dispersal.
  Seed of burdock in relation to balance of life.

A Communication.

Editor General Science Quarterly:

I trust that you will find many teachers endorsing your position regarding the differences between elementary science and general science expressed in the November number of the Quarterly. The whole subject of general science is still so new that our ideas with reference to it have not had time to crystallize. It is likely that many changes will have to be made before we can expect the study to be as well organized as some of the special sciences, but by taking thought in advance it may be possible to avoid some of the pitfalls into which we might otherwise flounder.

First of all, it seems to me, it is most important to emphasize the fact, which you have already indicated, that the presentation of the elementary parts of the special sciences cannot be regarded as constituting a course in general science. A real course in general science it seems to me, should be concerned with the general principles surrounding or underlying all science. The uncertainty in which the whole subject is at present involved is reflected in our text-books from which it would appear that even the authors themselves are far from agreeing as to what should constitute such a course. A number of excellent text-books now available are founded on one or more of the special sciences, but in my opinion, if general science, as distinct from nature study, commercial geography, and elementary science, is to succeed, it must very soon decide upon certain fundamentals and shape its course accordingly.

The demand for a course in general science is due to a variety of circumstances, but from the viewpoint of the high school, at least, it will best serve its purpose if it provides an introduction to the special sciences. There is no question but what the teaching of such sciences in a large number of schools has become so technical as to fairly demand an introductory course of this kind. But the course contemplated does not imply one consisting of an equal number of pages devoted to the elements of, say, physiology, physiography, botany, zoology, physics, and chemistry. It should, instead, treat of the principles upon which all these are based. What

these principles are may need considerable investigation to determine, but the sooner we set about the task of discovering them, the sooner will the general science movement be generally recognized as worthy of support.

Having decided what subjects should constitute or form part of the course the next step should be to induce teachers to adopt the laboratory method of presenting it. A good many otherwise intelligent teachers appear to be a bit afraid of a study that requires something actually to be done instead of talking or reciting about it. But the student needs an introduction to the methods of the laboratory and an understanding of the significance of an experiment quite as much as he needs the store of facts gained thereby. Fortunately most of the fundamental principles of science can be taught in an ordinary class-room equipped with water and gas, with materials easily obtained from the nearest kitchen and drug store. Even the beginning teacher should be encouraged to adopt this method. To make the course mainly recitational, or even to make it a course in observing experiments performed by the teacher is almost certainly to defeat its own ends and soon reduce it to the position of certain of the special sciences which through similar treatment are now obliged to fight for even a minor representation in the high school curriculum.

Above all, the course should be kept simple and within the comprehension of children not yet in their teens. Complicated apparatus, abstruse facts and the technicalities of commerce and manufactures have no place in such a course and should be rigidly excluded.

The special sciences are frequently charged with lack of practicality, indefiniteness of aim, poor organization, and a failure to correlate with other studies and their waning popularity in some sections is attributed to these defects. There are indications, however, that such imperfections are to be remedied and that science in time will be well organized and thoroughly correlated. This highly desirable state of affairs will be certainly advanced if general science, at the outset, so shapes its course that the more technical sciences can be built upon it.

WILLARD N. CLUTE.

Joliet, Ill., Jan. 3, 1918.

Food Conservation Exhibits for Teachers.

WILLIAM GOULD VINAL, THE RHODE ISLAND NORMAL SCHOOL.

Teachers have an important part to play in the winning of the war. Many of them feel the tremendous power they have at hand for carrying the message of conservation to the people through the children. Some have already brought into their teaching, incidental to language lessons or as a part of general science, the facts of food conservation. An exhibit was held at the Rhode Island Normal School on January 12, 1918, under the auspices of the Rhode Island Science Teacher's Association and under the direct supervision of the writer, to facilitate the exchange of these ideas. There was great ingenuity displayed in preparing material and it is felt that the readers of the QUARTERLY who were unable to attend the exhibition might like a brief resume of the results.

Direct aid was obtained from the State Federal Food Administrator, the Extension Department of the State College of Agriculture, and the Director of Home Economics for Rhode Island. An article printed for the United States Food Administration entitled *Graphic Exhibits on Food Conservation at Fairs and Expositions* is very suggestive for such work. Commercial exhibits were not combined with the teachers' exhibit at this time.

A list of some of the important projects will show the possibilities with the general unit *food conservation.*

Range of prices of sugar, potatoes, etc. during the period of the Revolutionary War, Civil War, etc.

Food obtainable in Massachusetts 1621-1629 and what they lacked.

Pioneer provisions in Alaska and what they now produce.

Food of the Romans and what foods were unknown to them.

Food on board the Santa Maria.

How to live on 24 cents per day.

Animal products of Narragansett Bay that we do not eat and ought to.

What the colonist ate that we neglect.

Food of the Narragansett Indians.

Help our boys save coal.

For meatless days.
Save soap.
Use more corn.
Why not send corn abroad.
Uses of sour milk.

The rural schools of Smithfield and Stillwater had been doing considerable in the line of food conservation. They served a Thanksgiving dinner to their parents, teachers, and the superintendent. For the exhibit they worked upon the so called Hoover Lunch Box. All sorts of combinations were worked out and then the four best, as judged by the children themselves, were sent to the Normal School.

An exhibit from the city schools, which should be spoken of was prepared by the children of the John Howland School, Miss Mary Williams, teacher. Every point was illustrated by colored pictures which the children had cut from advertisements in Good Housekeeping and other magazines.

The correlation with drawing was shown by the making of posters by the Normal School Classes under the supervision of Miss Marie Stillman. The possibilities in history, as suggested by the project headings, was enthusiastically dealt with by the Seniors, under the leadership of Mrs. Walter Stokes Irons. Professor R. M. Brown had geography material which pertained to the point. A world map to show the production of sugar gave opportunity for many to realize the part that the central powers had held in this industry. The importance of corn was shown in the oils, starches, sugar, syrups, gums, etc. exhibited by the Corn Products Refining Company.

Miss Adelaide Abell of the Technical High School prepared an exhibit to show what the soldiers need; what we can use in place of these things; and a wonderful meal for 22c. The following are recipes for making the things included in the meal.

CREAM OF PEANUT SOUP.

2 cups milk	1 slice onion
2 tablespoons peanut butter	1 teaspoon salt
1 tablespoon cornstarch	Pepper

Cream cornstarch and peanut butter, stir into heated milk. Cook until creamy and add seasonings.

SALMON LOAF.

1 cup fish
1 cup left-over bread or cracker crumbs
1 tablespoon chopped parsley
Pepper
1 tablespoon lemon juice
1 egg
½ teaspoon salt
½ cup milk

Mince fish, removing skin, etc. Soak crumbs in milk until soft. Mix fish and crumbs, add seasonings and beaten egg. Pack in greased moulds and bake in a pan of water until firm and delicate brown. Unmold and serve with peas or white sauce. (Use cornstarch in thickening white sauce.)

RYE AND CORN MUFFINS.

2 cups Indian meal
1 cup rye meal
2 cups sour milk
¼ cup molasses
1 egg
1 tablespoon Mazola
1 teaspoon soda
¼ teaspoon salt

Mix dry ingredients, beat in sour milk and molasses. Beat thoroughly and pour into greased pans. Bake 25-30 minutes.

OATMEAL COOKIES.

1½ cups brown sugar
2 cups rye flour
2 eggs
1 teaspoon soda
½ teaspoon salt
¼ cup raisins
1-3 cup mazola or cotton-seed oil
2 cups dry oatmeal
2 teaspoons cream of tartar
½ teaspoon cinnamon
¼ cup nuts

Mix dry ingredients. Beat egg until light, add creamed sugar and fat. Add dry ingredients, beating thoroughly. Drop from teaspoon 1 inch apart on a greased pan. Bake in moderate oven.

The pupils of Dr. Marian Weston prepared numerous graphic exhibits to show what we should save and their substitutes. Edible mushrooms and algae and herbs for greens were suggestive.

Dialogues appropriate for grade pupils were written for the occasion by Miss Frances Saville.

Food Lessons.[1]

Ida S. Harrington, Director of Home Economics for State of Rhode Island.

Success in the Food Conservation campaign depends on wider cooperation than we have yet brought about. The housewives alone cannot solve the problem. They must enlist the services of the men, the boys and girls, and most of all the children. Children are, of all people, the easiest to interest. All it needs is to let them have a finger in the pie. One of the problems we are trying to work out is the making of acceptable war breads, and, having made them, to enlist the willingness of our household to eat the product. No surer way of capturing the children's interest can be found than to let them make a loaf of war bread, nor does this require domestic science equipment. The teacher and her class may find inspiration in making an imaginary loaf.

First explain to the children that bread making is really gardening on a very small scale. We sow a crop, the yeast plant, in a field (the dough) which must furnish all the essentials for growth, that is warmth, moisture, air, food, and room to grow. The yeast cake, which is to make our crop, is composed of a large number of very tiny plants all crowded together and having been put to sleep by taking from them all, or nearly all, of their required moisture. Two things are needed before they can work their magic. First they must be separated, like children in a school room. The little plants will not do good work when their heads are crowded close together. Such a group means mischief, not work, as every teacher knows. Next they must have water added to them. A very good illustration, if not a strictly scientific one, is to show a box of Japanese water flowers crowded together and inert and put some of them into a glass of water, showing how they expand and move apart. The next illustration is to bring out how greatly flours differ in giving the yeast plant room to grow. Have the children take a half a cup each of flour or five different kinds of flour and mix each into a little ball of dough. Put these into squares of cheesecloth and wash them in bowls of water until the starch part

[1]Given before R. I. Science Teachers' Association, Jan. 12, 1918.

of the flour has been washed out. What remains in the cheesecloth will be that rubbery, stretchy substance which we call gluten and which is needed to make dough elastic. The next illustration shows how, under good conditions, the yeast plant actually does its work. Make a small lump of dough, using about a cup of flour and ¼ cup of lukewarm water in which a cake of yeast has been dissolved. Knead the little ball of dough until it is smooth and elastic. Then put it into a pint of water as warm as the hand can bear. It will sink to the bottom and show no signs of life, but as we watch it, it will gradually begin to rise in the water and in about fifteen minutes will float on the surface, a light, spongy mass, somewhat resembling a jelly fish. Having actually seen the magic "work while you watch" the process of bread making will become one of vital interest to children. It will lead naturally to their preparing first samples of dough and afterwards rolls and bread at home and bringing them in to be judged by a jury of pupils. No child who has made war bread for a competition and taken a prize will refuse to eat the prize product. Wheatless days will have no further terrors for that child.

It has often been demonstrated in other lines of work how helpful the making of exhibits is in arousing the pupils' interest. Witness the exhibits shown here today which could not have been what they are had they not been prepared with whole-hearted interest.

Finally there is a strong dramatic instinct in children which may be counted on to develop their interest in food conservation as it has done in other topics. A very successful production of a Hoover play entitled "Uncle Sam's Visit to Rhode Island" was given by the Sunday School of the Cranston Street Baptist Church recently. It brought out how small is the number of things which we are asked to save and how large the number of possible substitutes. The boy who represented White Bread was quite lost sight of by the time the various War Breads had appeared on the stage. The child who impersonated the Butter Ball sank into insignificance before the charms of Miss Beef Drippins who was adorned with a helmet promoted from the ranks of saucepans, and from which dangled streamers to simulate streams of fat.

The lesson of purpose and patriotism was driven home by the fact that no character approached Uncle Sam without saluting him and the flag. At the end of the performance the audience as

a whole gave the salute and joined in the singing of America.

While a performance like the above would require large numbers and more preparation than could be furnished in the average school, there is no lack of simple dialogues which could be used. The one appended, "Food Army Recruits", written by Miss Frances E. Saville, could be given with a minimum of preparatory work. The article entitled "The Home Guard" in the December number of the Home Economics Journal could be most successfully adapted to dialogue form. Anything that proves to children that they are important factors in the national work we have undertaken means surer cooperation now and better citizenship in the days to come.

Food Army Recruits.

By Frances E. Saville.

Scene: *Family Dining Room.*

Bob. (*Reading paper*). "Another slacker caught at Glendale" (*looking up*) Say Jack, wouldn't you hate to be a slacker?

Jess. You needn't say anything, Bob Manning, you are a slacker and so is Jack.

Both. What!

Jess. Yes, you are slackers.

Jack. How are we slackers? We have not been called to be soldiers and if we were called you bet we'd go, wouldn't we, Bob?

Bob. You bet we'd go. I wish I was old enough to go right now.

Jess. Well, Miss Judson says we must all be soldiers and that is why I called you slackers for you are not answering to the call to be the kind of soldiers she told us about in school today.

Bob. What kind of a soldier is that, sis?

Jess. A soldier in the food army. Didn't Mr. Smith tell you about it in your room today?

Jack. Yes, he did tell us something about it but I didn't pay much attention.

Prue. (*much younger*) Miss Haley told us about it today, too. She said we could all join the Food Army and in arithmetic we counted up in our lesson how many pounds of sugar would be

saved in a week, if every member of our families used one teaspoonful less every day.

Bob. How much was it, Prue?

Prue. Fifteen pounds, seven ounces, and three-quarters.

Jess. And you used three spoonfuls on your oatmeal this morning, Bob, and that's why I called you a slacker.

Prue. Well I guess we are all slackers that way but I'm going to try to use less so the poor little French and Belgian children can have more.

Jack. I tell you what let's do. Let's form a Junior Food Army Corp and pledge ourselves to follow out all the rules Mr. Hoover has laid down for us.

Jess. That means less sugar on your oatmeal, Bob.

Bob. Well, I'll give it up if you'll give up your candy at recess time.

Jack. And I'll stop chewing gum and give the money to the Red Cross instead.

Prue. And I'll try to eat corn bread without finding fault, but I do hate it.

Jess. Let's all give up our toast for breakfast and eat more oatmeal instead so that will make our wheatless meal every day.

Prue. Have we got to eat Johnny cake both Wednesday and Thursday too?

Jess. No, we can have oatmeal bread, rye bread, and barley bread, as well. Miss Lathrop is going to teach us to make war bread in cooking class.

Jack. And I suppose you'll come home and make some and we'll have to eat it. Well, a man can't die for his country but once. How will this look on my tombstone? "Here lies John Manning. Died at the age of fourteen years from eating war bread. He gave his life for his country."

Bob. Well, what else must we do?

Jess. No meat on Tuesday and Friday and no pork on Saturday.

Bob. Then we can't have any baked beans for Saturday night.

Jess. Oh yes we can have them! Mr. Hoover says New England people may have pork in their beans as usual, and we can have brown bread as often as we can persuade mother to make it. It will help out our wheatless days.

Jack. Good idea, sis.

Prue. I like brown bread better than Johnny cake particularly if Mary puts raisins in it.

Jess. Yes, and we don't any of us want to be slackers in the Food Army for that is one way we can help win the war.

Bob. Of course we don't want to be slackers and you won't have a chance to call me a slacker again on that score.

Jack. Nor I. I'll eat war bread if it does kill me.

Jess. Since we can't go to fight let's all do our best right here at home by making the best of our war food for we have so much more than the poor children in France and Belgium and what we save goes to them.

Prue. And teacher says if we all save a little there will be plenty for us and them too.

Bibliography of General Science for 1917

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A year ago the writer published in General Science Quarterly a bibliography of general science to the end of 1916. At that time a request was made for corrections and additions to the list. No corrections and few additions have been sent in.

The present contribution is intended to bring the bibliography down to the end of 1917. All articles known to the writer and dealing directly with general science have been included. It is not supposed, however, that everything published has been found. It is particularly difficult to keep track of local and state publications. The writer will therefore take it as a courtesy if citations or separates are sent to him, either of articles published heretofore and not listed or of articles to be published in the future.

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Color Blindness.

PAUL AMMON MAXWELL, AVALON, PA.

THE PROJECT. The human eye offers many interesting projects for use in general science courses, among them the project of color blindness. A thorough study of this subject will not only be useful, but also attractive to the majority of pupils.

Probably the best method of procedure is to first make clear the normal processes of color vision in order to then explan the abnormal condition which makes one insensible to certain colors. Such a plan will be followed in this discussion.

THE MECHANISM OF THE EYE. Most high school pupils are familiar with the mechanism of the camera and it is therefore advisable to consider the eye as a spherical camera having a shutter, diaphram, lens, plate, etc. When light enters the pupil of the eye it is refracted by the lens and brought to a focus upon the inner wall of the eye-ball which, like the plate of a camera, is sensitive to light. This inner wall or "retina" of the eye is made up of thousands of minute structures, "rods" and "cones", each of which is the terminus of a nerve fibre leading from the optic nerve. It is these rods and cones which receive the stimuli in the form of light and are so affected that sensations of sight result. The rods function in forming sensations of white, black or gray; the cones in forming color sensations.

THE NATURE OF LIGHT. In order to understand the physical nature of light a sharp distinction must be made between light as it appears to us in sensations and light as a form of energy. Light in a physical sense is a type of wave motion traveling here and there in space very much like sound and water waves. Like these

other waves light waves may vary in length and may be of different vibration rates. For instance it is known that light waves vary in length from about 300 to 2,000 millionths of a millimeter. The human eye is sensitive to all waves between 393 and 759 millionths of a millimeter in length, waves outside of these limits not producing sensations of sight.

VISUAL SENSATIONS. Sunlight and artificial white light are mixtures of waves of various lengths. If sunlight falls upon an object which is capable of reflecting all wave lengths from it, the object appears white or gray when the light enters the eye. If the object, however, only reflects light waves of certain lengths to the eye, absorbing the rest, it is said to have color. Each particular wave length produces a particular hue.

There are thus two aspects of visual sensations which must be treated separately; the chromatic or color aspect in which the various hues are the center of interest and the achromatic or black-white aspect in which the relative brightness of objects is considered. In explaining the color aspect, psychologists assert that there are but four primary hues; or better, two pair of primary hues which are red-green and yellow-blue. There is a particular

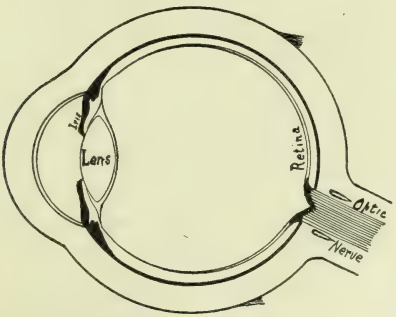

Fig. 1. The Human Eye.

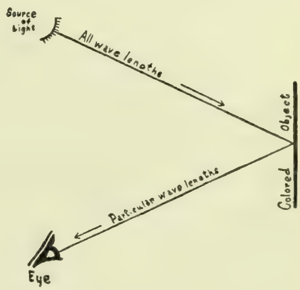

Fig. 2. Color Sensation by Reflected Light.

type of cone in the retina for each pair. When red light enters the eye, the red-green cones, are stimulated and a chemical action is set up producing the corresponding red sensation. If green light enters the eye, the same red-green cones are stimulated, but the action is in the reversed direction. The blue-yellow cones function in exactly the same manner.

The question now arises as to how the secondary or mixed hues are produced. A study of figure (3) will answer this. It is

known that when red and yellow light waves are mixed and the red and yellow actions in the cones are thereby aroused simultaneously, intermediate sensations such as orange result. But a similar sensation may be produced by light waves of a certain length. Now the red reaction is aroused by light waves of about six hundred (600) to seven hundred (700) millionths of a millimeter and the yellow reaction by waves from five hundred (500) to six hundred and fifty (650) millionths of a millimeter in length. Thus, the orange sensation may be produced by a mixture of waves varying from five hundred (500) to seven hundred (700) millionths of a millimeter, or by particular waves between six hundred (600) and six hundred fifty (650) millionths of a millimeter which act upon both types of cones. In a similar way, if the green and yellow or the green and blue reactions are produced simultaneously, intermediate hues result. In order to produce hues between red and blue, such as purple, the two types of waves must of course be mixed.

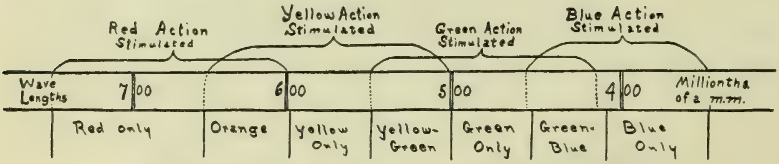

Fig. 3. Action of Light Waves Upon the Cones.

The best way to mix colors is by the use of the color mixer or the color top, which are mechanisms for rotating two or more segments of colored paper so rapidly that light is reflected to the eye from all segments at practically the same time. If either the top or the mixer is available it will be helpful to have the pupils produce all the hues from various mixtures of the four primary ones. By adding black or white, shades and tints may also be produced. It is interesting to attempt the formation of green by mixing blue and yellow which is of course impossible, since blue and yellow light waves act upon the same cones setting up opposite actions which tend to neutralize each other. Likewise there is no sensation of color when red and green light waves are mixed. Many people must be shown this to believe it, on account of the fact that the artist obtains a green pigment by mixing blue and yellow pigments.

The achromatic or black-white aspect of visual sensation is concerned with the rods of the retina. When light of various colors

enters the eye, the four primary color reactions in the cones neutralize each other. The rods, however, are stimulated and a sensation of gray results. If an object reflects all the white light from it, a certain chemical reaction takes place in the rods and the object appears white. If no white light is reflected an opposite reaction takes place and the object appears black. When only a part of the white light is reflected to the eye, some rods react one way, others, the other way, and a sensation of gray results. Objects of particular hues usually reflect more or less white light as well as their particular sort. This produces shades and tints.

COLOR ZONES OF THE RETINA. In connection with the above theory* of visual sensations it is interesting to study the locations of the rods and the cones upon the retina. Figure 4 is a diagram of the rear hemisphere of the eye-ball. There are three retinal zones; the central zone upon the extreme rear wall of the eye; the intermediate zone bordering upon the central zone; and the outer zone next to the intermediate zone. Now both types of cones are found upon the central zone, only the blue-yellow cones upon the intermediate zone and no cones upon the outer zone. The rods

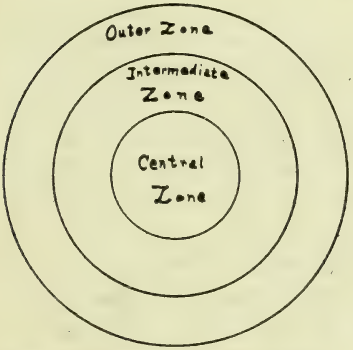

Fig. 4. The Color Zones of the Retina.

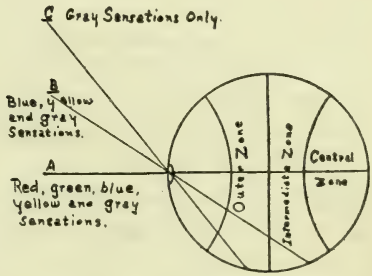

Fig. 5. Color Zones and the Field of Vision.

are scattered over all zones decreasing in abundance from the outer zone to the center of the central zone. Hence, as shown in figure (5), an object of any color such as (A) may be distinguished if it is in the center of one's field of vision and therefore reflecting light to the central retinal zone. Only objects of blue, yellow or gray or their mixed hues appear natural however in such a position as (B), for the reflected light falls in the intermediate zone

*The Herring Theory of Color Vision which is accepted by all leading psychologists.

where there are no red-green cones, with the result that red and green objects in such a position appear gray. All objects in position (C) appear gray as they reflect light to the outer zone where no cones are found. In this figure the eye is, of course, understood to be constantly focused upon point (A).

COLOR BLINDNESS. When there are no cones present in the retina of his eye a person sees everything as white, gray or black, since only the rods are stimulated. Such a condition is very rare. Absence of one type of cone, however is a common occurrence and it is usually the red-green type that is absent. To a person without red-green cones all objects appear gray that would otherwise appear red, green or any hue dependent upon the red-green cones such as purple, orange, peacock and lemon. In the rare case of blue-yellow blindness, objects that should appear blue, yellow or any mixed hue look gray. The absence of both rods and cones from the retina means total blindness.

TESTS FOR COLOR BLINDNESS. Since red-green blindness is the only common form, most tests are only concerned with this type. Following is a description of one test* which is typical. There are three standard skeins of colored wool, one green, one old rose, one dark red, and forty match skeins, all numbered. The person being examined is given the standard green skein and is told to pick out all the match skeins of the same hue. If he picks all the even numbers up to twenty (the numbers are not visible) and no others it is reasonably certain that he is not color blind since these skeins are the only ones of a green hue. The others are various colors designed to confuse the subject. As a check upon the first test a similar procedure is followed using the standard old rose. The even numbers from twenty-two to thirty are the proper matches in this case. The third standard is merely a counter check and is seldom necessary.

A very good test of this type can easily be arranged either by the teacher or the pupils, using colored paper instead of the wools.

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*Holmgrens Wools.

Books Received.

Elementary Economic Geography, by Charles R. Dryer, American Book Company, 415 pp.

Commerce and industry are vital subjects in America today. This book has very successfully met the difficulties which confront young pupils (grades 7 to 9) who undertake the study. In this book the author shows a new way of using geographical material, relating environment, resources, industries and products useful to man. By far the greater part of the book is devoted to the economic geography of the United States.

Industries hold so much in common with general science and geography that general science teachers will be interested in this book. It is well illustrated with maps, line cuts, and half-tones.

General Science Book Reviews.

Experimental General Science. By Willard N. Clute. P. Blakiston's Son & Company. 304 pp.

This small volume contains 42 chapters. Thirty chapters deal with physical and chemical sciences. The chapter titles cover pretty well the usual titles in physics and the simpler ones in chemistry. The last twelve chapters deal with biological science, about half of which might be termed physiology. Among chapters dealing with life are "Living Things", "Evolution", and "Bacteria". The last nine chapters all refer to the human body and treat of "The Framework", "The Governor", "The Nourishment", "The Transporting System", "The Ventillating System", "The Covering", "The Excretion of Waste", "The Special Senses", and the "Effect of Drugs."

The book is written to meet the need of an introduction to the special sciences as well as furnish those who leave school early with a fund of "fundamental principles which are very essential to their success and happiness of life". The general style of the book is suited better to the older than to the younger pupils. The book is illustrated with numerous line cuts. There is a very good list of practical questions at the chapter ends, mixed with these questions are numerous suggestive experiments which pupils ought to perform either in school or at home.

Science for Beginners. By Delos Fall. World Book Company, 382 pp., 34 chapters.

The opening chapters of this book discuss with the pupil in a rather unique and pleasing way how he may develop a scientific attitude toward things. This is followed by "Matter", "Properties and

Changes in Matter", "Oxygen", "Hydrogen", and "The Study of Water". Among the chapter titles which entice you to read are "A Pinch of Salt", "A Cake of Soap", "A Loaf of Bread", "The Limestone Story", "Aids to our Work". The pupil is given an introduction to minerals, rocks, and to the soil. The potato takes a chapter to itself. Other chapter titles more commonly found in texts are "The Study of the Air", "Weather", "Matter and Motion", "Sound", "Heat", "Temperature", "Light", "Electricity", "Work and Energy".

No seventh or eighth grade pupils can fail to be interested in this book. It is written in a style which appeals to young pupils. Illustrations which are real pictures are used instead of diagrams. Although there is no connecting organization running through the book many chapters grouped together are closely related and give as much organization of matter as young pupils need.

Many exercises are suggested. These may be demonstrated or performed individually. Some of them can be done as home experiments. True to its title the book is an admirable one in "science for beginners."

General Science. By CHARLES H. LAKE. Silver, Burdett & Co., 438 pp.

The book is divided into twenty-four chapters. The first chapter deals with the earth as a heavenly body. The next three on matter, energy, and machines, give the simpler principles of physics relating to these subjects. In the chapters on atmosphere and water there are brought together from various fields of science many important facts and principles. Heat and weather receive the attention which such important subjects require. In the discussion of magnetism and electricity the author fearlessly introduces the pupil to electrons. Sound and light are briefly treated. The subjects fuels, common compounds, soils and drainage complete the physical science treatment and lead to the last six chapters which deal on life of the earth. These last chapters deal with plants, animal life, man's place in nature, foods and nutrition and community sanitation.

The book shows an attempt at organization in so far as the matter in each chapter is more or less related to previous chapters. This will be welcomed by many teachers. From a science standpoint, the work is well done. The material covered furnishes a substantial foundation for future science work or for general science purposes. The book is rather advanced for seventh and eighth grades but will serve for ninth and first year high school grades. The use of questions at the chapter ends is a good feature, but the omission of an index is unfortunate.

The book is very attractive in appearance and is very well illustrated with half-tones and line cuts. There are seventy-nine experiments in fine print. These are suitable for class demonstration and in some cases for home experiments.

Science in Current Periodicals.

AEROPLANES

The Problem of Making 4000 Aeroplanes a Month.—Cur. Opin. 64:62 Jan. 1918.

America's Air Service. Ill. Describes work of preparing a fleet of aeroplanes and training men to operate them. W. A. Durand.—Jo. Franklin Inst. 185:1-27. Jan. 1918.

Uncle Sam's Ground School for Flyers. Practical Experience in "Spotting". Ill. C. H. Claudy.—Sc. Am. 118:69. Jan. 19, 1918.

ALCOHOL

Relation of Alcohol to Fatigue.—Cur. Opin. 64:39. Jan. 1918.

ASTRONOMY

The Heavens in February. Our nearest Stellar Neighbor. H. N. Russell.—Sc. Am. 118:108. Feb. 2, 1918.

ATOMS

The Experiences of an Iron Atom. The Cycle of its Life History. C. R. Sturdevant. Part I. Sc. Am. Sup. (No. 2192). 85:14—16. Jan. 5, 1918. Part II. Sc. Am. Sup. (No. 2193). 85:30—32. Jan. 12, 1918.

AUTOMOBILE

Automobile Development During 1918. V. W. Page. Sc. Am. 118:16. Jan. 5, 1918.

The Place of the Automobile in Years to Come. John R. Eustis. Sc. Am. 118:16. Jan. 5, 1918.

The Motor Car of the Future. Ill. C. H. Claudy. Sc. Am. 118:5. Jan. 5, 1918.

Keeping the Cooling System Hot. J. S. Harwhite. Sc. Am. 118:11. Jan. 5, 1918.

Winter Care of Automobiles. (Formulas for Anti-Freezing Radiator Solution.) Victor W. Page. Ev. Eng. Mag. 4:172-173. Jan. 1918.

AVIATION

What the War Has Done for Aviation. Ill. R. M. Roy. Ev. Eng. Mag. 4:2-13. Feb. 1918.

Ten excellent articles well illustrated in the "Aviation Number." Nat. Geog. Mag. 23:101-114. Jan. 1918.

BANANA

The Banana: A Food of Exceptional Value. S. C. Prescott. Scientific Monthly. 6:128-141. Jan. 1918.

BEES

How Bees Produce Honeycomb. Edward F. Bigelow. Ill. Guide to Nature. 10:259-272. Feb. 1918.

BIOLOGY

Is Modern Biology Based upon a Misconception of Fact? Cur. Opin. 64:33. Jan. 1918.

CANAL

N. Y. State Barge Canal. Ill. D. B. La Du. Sc. Am. 118:56-57. Jan. 12, 1918.

COAL

The Efficient Use of Coal. Century. 95:602-604. Feb. 1918.

COLOR

1. The Potentiality of Color in Lighting. M. Luckiesh. pp. 1-6.
2. Color from the Physical Point of View. H. C. Richards. pp. 7-13.
3. Color in Illumination. Beatrice Irwin. pp. 14-20.
4. Psychology of Color in Relation to Illumination. L. T. Troland. pp. 21-37.
5. Color Standards. U. S. Bureau of Standards. J. G. Priest. pp. 38-49.
6. Some Experiments on the Eye with Different Illuminants. C. E. Ferree and G. Rand. pp. 50-60. Trans. Ill. Eng. Soc. 13:1-82. Feb. 1918.

CUCKOOS

The Cuckoos. Ill. A. A. Allen. Am. For. 24:21-24. Jan. 1918.

DICTOGRAPH

Novel Applications of the Dictograph. El. Exp. 5:605 Jan. 1918.

DIVING

Deep-water Diving. Ill. Sc. Am. 118:60. Jan. 12, 1918.

ELECTRICITY

Soothing Our Soldiers Electrically. (High Frequency Electricity.) L. E. Darling. Pop. Sc. Mo. 92:210-212. Feb. 1918.

Storage Batteries. Peter J. M. Clute. Pop. Sc. Mo. 92:311-312.

ELECTRON

Modern Physics and the Electron. (Describes work of R. A. Millikan.) El. Exp. 5:602-603. Jan. 1918.

The Electron Theory. Prof. W. A. Noyes gives a clear presentation developed historically. Jo. Franklin Inst. 185:59-74. Jan. 1918.

ELEMENTS

The Complexity of the Chemical Elements: Electrical Relations, Radio-Activity and the Nuclear Theory. F. Soddy. Sc. Am. Sup. (No. 2196). 85:78-80. (No. 2197). 85:94-96. Feb. 2 and Feb. 9, 1918.

EXPLOSIVES

High Explosives. Ill. Gustave Reinberg, Jr. Ev. Eng. Mag. 4:174-176. Jan. 1918.

FOOD

Bureau of Markets and its Relation to the Conservation of Food. (Gives reasons why we must be saving of meats and cereals.) Chas. J. Brand. Jo. Ind. & Eng. Chem. 10:66-69. Jan. 1918.

Edible Fats in War and Law. David Wesson. Jo. Ind. & Eng. Chem. 10:71-73. Jan. 1918.

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The Canning Industry. H. A. Baker. Jo. Ind. & Eng. Chem. 10:69-71. Jan. 1918.

Edible Reptiles. Lit. Dig. 56:2:23. Jan. 12, 1918.

One page is devoted to discussion of food in each issue of the Literary Digest.

FREIGHT CAR

Convertible Cars for Rough Freight. Ill. Lit. Dig. 56:6:25. Feb. 8, 1918.

FUEL

Fuel Value of Wood. Lit. Dig. 56:1-19. Jan. 5, 1918.

To Win the War with Coal. Lit. Dig. 56:1-18. Jan. 5, 1918.

Solving the Fuel Problem. Garden Mag. 26:196. Jan. 1918.

Putting out a Burning Coal Pile. Lit. Dig. 56:1-20.

Some Ways of Saving Coal. W. K. Jacques. Pop. Mech. 29:212. Feb. 1918.

Sound Advice on Coal Saving. Pop. Sc. Mo. 92:297-298. Feb. 1918.

GARDENS

The Beginners Garden. W. C. McCollom. Garden Mag. 26:188-190. Jan. 1918.

The Patriotic Garden. Grace Tabor. Garden Mag. 26:191-194. Jan. 1918.

The Patriotic Garden (Fruit Trees). M. G. Kains. Gar. Mag. 27:16-18. Feb. 1918.

Gardening on the "Machine-to-Win-the-War" Basis. Adolph Kruhm. Gar. Mag. 27:28-30. Feb. 1918.

GAS

Toluol Recovery and Standards for Gas Quality. R. S. McBride. Jo. Ind. & Eng. Chem. 10:111-114. Feb. 1918.

GLASS

The Glass, and Glassware Industry. (Geography). J. J. MacFarlane. Com'l. Am. 14:13-17. Dec. 1917.

HEATING AND VENTILATION

Self-operating Humidifier for Hot Air Furnace. Pop Mech. 29:99. Jan. 1918.

The Dessert Aridity of Heated Houses. Geog. Rev. 5:77. Jan. 1918.

HEREDITY

The Collocation of Plasmas within the Cell: A Survey of a Mechanical Theory of Heredity. L. Legrand. Sc. Am. Sup. (Nos. 2195 and 2196). 85:60-64 and 76-77. Jan. 26 and Feb. 2, 1918.

HOT WATER SUPPLY

Hot and Cold Water in the Farm Kitchen. Sc. Am. 118:109. Feb. 2, 1918.

HYGIENE

The High Heel in Motion Picture and X-Ray. Ill. Jacques Boyer. Sc. Am. 118:102. Feb. 2, 1918.

MATTER

Misconception Regarding the New Theory of Matter. Pub. Opin. 64:115. Feb. 1918.

METEOROLOGY

Meteorology and the National Welfare. A. McAdie. Scientific Monthly. 6:176-187. Feb. 1918.

Chinese Contributions to Meteorology. Co-Ching Chu. Geog. Rev. 5:136-139. Feb. 1918.

MICROSCOPE

The Ultra-Microscope. F. W. Gentry. El. Exp. 5:623. Jan. 1918.

MINERAL PRODUCTS

The Foundations of Power or the Mineral Wealth of the United States. J. J. MacFarlane. Com'l. Amer. 14:15-21. Jan. 1918.

MISCELLANEOUS

The Crewless Raider. Lit. Dig. 56:2-24. Jan. 12, 1918.

The Worlds Largest Coal Car. (120 Tons Capacity.) Com'l. Am. 14:25-27. Dec. 1917.

Feeding a Zoo in War Times. W. D. Goodwin. Pop. Mech. 29:51-54. Jan. 1918.

America's Cantonments. Ill. Nat. Geog. Mag. 32:421-476. Nov.-Dec. 1917.

MOTION PICTURES

Micro-Photoplays. Ill. A. C. Lescarboura. Sc. Am. 118:72-73. Jan. 1918.

NATURE STUDY

Domestic Animals, etc. 16 pp. of photogravure, excellent reproduction secured with reflectoscope. Nat. Geog. Mag. 32:519-534. Nov.-Dec. 1917.

NITROGEN

The Romance of Nitrogen. Ill. Littell McClung. Ill. World. 28:853-855. Feb. 1918.

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Gun Cotton in Peace. Gustave Reinberg, Jr. Ev. Eng. Mag. 4:218. Feb. 1918.

PHOSPHORUS

The Geologic Role of Phosphorus. E. Blackwelder. Sc. Am. Sup. (No. 2197). 85:92-94. Feb. 9, 1918.

PHOTOGRAPHY

The Printing Box for the Amateur Photographer. J. G. Albright. El. Exp. 5:696. Feb. 1918.

Some Points in Photo-Copying. Sc. Am. Sup. (No. 2194). 85:38. Jan. 1918.

PLANT PESTS

Laying the Bugaboo of Disease (Distribution and Control of Potato Blight, Peach-Leaf-Curl, Rust Fungi, Rust Pests of Pines, and White Pine Blister Rust.) W. H. Rankin. Gar. Mag. 27:28. Feb. 1918.

POTASH

Nebraska Potash. (Potash from the alkali lakes.) Lit. Dig. 55:26:28. Dec. 29, 1917.

POTHOLES

Potholes. Ill. E. L. Elston. Scientific Mo. 6:37-51. Jan. 1918.

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Rainfall and Battles. R. De. C. Ward. (There is no evidence that explosives cause rainfall.) Geog. Rev. 5:151. Feb. 1918.

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Roads—Good and Bad. Ill. Sc. Am. 118:12-13. Jan. 5, 1918.

SCIENCE

Practical Importance of the War Between Science and the Classics. Pub. Opin. 64:114-115. Feb. 1918.

SHIPS

The Marine Use of Concrete. Ill. Sc. Am. 118:81. Jan. 26, 1918.

Standard Steel Cargo Ships. Ill. Sc. Am. 118:8. Jan. 5, 1918.

Are We Building Real Ships? Ill. Sc. Am. 118:150-151. Feb. 16, 1918.

SNOW

Snow and its Value to Farmers. Ill. A. H. Palmer. Scientific Mo. 6:128-141. Feb. 1918.

SOLDIERS

The Nerves of a Soldier. A Salsbury. Sc. Am. 118:14. Jan. 5, 1918.

Magazine List

Agricultural Digest. 2 W. 45 St., N. Y. Monthly. 15c a copy, $1.50 a year. Ill. Has suggestions for teachers interested in school gardens and agriculture.

American Forestry. Washington, D. C. Monthly, 25c a copy. Splendid pictures for plant and tree study.

Commercial America, Phila. Com'l Museum, Phila., Pa., $2.00 a year. Ill. Commercial production. New Inventions. Will interest commercial geography and science teachers.

Current Opinion. 65 W. 36 St., N. Y. Monthly, 25c a copy, $3.00 a year. Has a regular department "Science and Discovery" containing articles of popular interest, adapted to pupil or teacher's use.

Electrical Experimenter. 233 Fulton St., N. Y. Monthly. 15c a copy. $1.50 a year. Ill. Popular articles on electrical subjects which fascinate elementary and high school pupils. Many suggestions for teachers.

Everday Engineering Magazine. 33 W. 42 St., N. Y. Monthly. 10c a copy, $1.00 a year. Ill. Popular articles on science and mechanics. Much of it is simple enough for elementary pupils.

Garden Magazine. Garden City, N. Y. Monthly. 25c a copy, $2.00 a year. Ill. Helpful to amateur gardeners, teachers and pupils.

Geographic Review. West 156 St., N. Y. Monthly. 50c a copy, $5.00 a year. Has good pictures. Of particular interest to geography teachers.

The Guide to Nature. Sound Beach, Conn. Monthly. 10c a copy, $1.00 a year. Ill. Of interest to elementary pupils and teachers of nature study.

Illustrated World. Drexel Ave. and 58th St., Chicago. Monthly. 15c a copy, $2.00 a year. Many short articles on applications of science and mechanics. Popular in style and attractive to elementary and high school pupils.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly. 50c a copy, $5.00 a year. Ill. A technical journal. Contains many articles of value to science teachers.

Journal of Home Economics. 1121 Cathedral St., Baltimore. Monthly. 25c a copy, $2.00 a year. For teachers.

The Literary Digest. 354 Fourth Ave., N. Y. Weekly. 10c a copy, $3.00 a year. Has a department "Science and Invention". Articles are mostly digests from other journals. They are popular in nature and suitable for high school pupils.

Journal of Industrial and Engineering Chemistry. Box 505, Washington, D. C. 60c a copy, $6.00 a year. A technical journal which contains much material which teachers can use. Monthly.

National Geographic Magazine. Washington, D. C. Monthly. 25c a copy, $2.50 a year. Best monthly journal for high grade pictures. Articles are of interest to general reader, pupils and teachers, as well as to geographers.

Nature Study Review. Ithaca, N. Y. Monthly. 15c a copy, $1.00 a year. An illustrated journal for teachers of nature study.

Popular Mechanics Magazine. Chicago. Monthly. 15c a copy, $1.50 a year. Short science items and articles well illustrated. Appeals strongly to elementary pupils. Suggests many construction projects.

Popular Science Monthly. 239 Fourth Ave., N. Y. Monthly. 15c a copy, $1.50 a year. Short science items and articles well illustrated. Appeals strongly to elementary pupils. Suggests construction projects.

School Science and Mathematics. Chicago. Monthly. $2.50 a year. A teacher's journal. Includes many helpful suggestions.

Scientific American. Woolworth Building, N. Y. Weekly. 10c a copy, $4.00 a year. Has longer articles than the other popular science journals. Illustrated and is particularly valuable to high school science pupils and teachers.

Scientific American Supplement. Woolworth Building, N. Y. Weekly. 10c a copy, $5.00 a year. Rather technical, but the majority of articles are usable by science teachers and some of them will do for pupil reference. Illustrated.

Scientific Monthly. Garrison, N. Y. 30c a copy, $3.00 a year. Articles as a rule are more along lines of pure science. Much of value to teachers and occasionally articles can be read to advantage by pupils.

Transactions of the Illuminating Engineering Society. 29 W. 39th St., N. Y. Monthly. 75c a copy, $5.00 a year. Technical. Many articles contain material which can be used in high school classes.

General Science Quarterly

Vol. II. MAY, 1918 No. 4

Science Work in the Speyer School.[1]

Morris Meister, Teachers College, Columbia University.

The war is the most vital factor in the world today. America is the most vital factor in the war. Education is the most vital permanent factor in America. Science, considered in the large, can and must become the most vital factor in Education. We, to whom has been entrusted this dominant note of modern life, are now confronted with the golden opportunity for change which comes with every cataclysm in life.

These rather bold statements describe to my mind the nature and direction of educational thought and activity of the last two years. And in the almost feverish desire which exists to do and to do quickly, no movement more than the junior high school movement has been the outlet for educational endeavor. The junior high school seems to have become the vehicle for "Democracy in Education." It presents a field from which tradition is gone; a field where ideas can be put into practice with a minimum of disturbance to existing systems; and it gives us the golden opportunity for change. The Speyer School represents a piece of concrete experimentation with the junior high school idea, and has drawn inspiration and was meant to function in this educational background.

About two years ago the New York City Board of Education and Teachers College decided to co-operate in an experiment. The city supplied 250 boys chosen from as many districts as was possible, who were about to enter the seventh grade. Psychological and other tests as well as teachers' tests and opinions proved the group to be an entirely average and representative group of New York City boys. The attempt was to be made to fit these boys for second year high school in the last two years of the elementary grade. The administration of the school was in the hands of the

1 Paper read at the Science Round Table, Teachers College Alumni Conferences of 1918

city; while Teachers College supplied the teachers of special subjects with Prof. Briggs as educational adviser for the school. Among the many important and interesting features of the experiment, I wish but to mention the unique provision for Individual Differences, which affected immensely the work in every subject. The boys of the school were divided into ten nearly equal groups; group 1 being the best, group 2, the next best, and so on down to group ten which was the poorest. The basis for classification, was again, psychological tests and educational scales and standards coupled with teachers' opinions. As better knowledge of the individual was obtained, a continual readjustment of groups was kept up. The result was that after two years our group one *was* group one in every subject and in every school activity—even to that of raising Red Cross funds. The educational possiblities in dealing with classes of such uniform ability and attainment are too evident to need further discussion.

The two-year period for experimentation is now over. We have sent our first batch of boys into the second year of the Senior High Schools of the city and are awaiting results. In the meantime, the tide of events in New York has suddenly swept the 6-3-3 plan or Junior High School movement into prominence. The president of the New York Board of Education, proposes a reorganization of the entire city system on the Junior High School basis; and Prof. Briggs, fresh from his studies and experiments in the Speyer School, has been called upon to advise in the reconstruction.

Science at the Speyer School is given twice a week for an hour each time. Our science room is a former cooking room which came to us entirely unmodified and our equipment throughout the two years was practically nil—owing to the slow moving wheels of our city system. We were supplied with six of the recent texts in general science and with a permit to loan apparatus from the Teachers College laboratory, when that apparatus was not there in use. These were rather trying circumstances; especially since it was the idea from the start to teach by the project method, a method so new to class-room procedure, as to offer in itself sufficient difficulties.

The project method in theory, has been discussed, evaluated, and urged by Prof. Dewey, Prof. Kilpatrick, and others, while in science teaching, Prof. Woodhull has done most in applying the idea. In the following outline, I have tried to summarize the

situation in project teaching as I see it. The ideas are fine, definite and clear. The carrying of these ideas into practice is still to be done.

THE PROJECT METHOD.

A. Historical Sketch

(1) The famous pioneers of science such as Faraday, Davy, Huxley, and Tyndall advocate in their work, method and teachings an attitude and study of science which is identical with the project method.

(2) With the report of the Committee of Ten standardizing one year of science for college entrance, science teaching became a formalized subject removed from actual life problems.

(3) The project movement is virtually a reaction toward the popularization of science advocated by Tyndall, Huxley and the rest—with modern philosophy and psychology of education as a back-ground.

B. The movement.

(1) It is closely allied with the spirit of democracy in education.

- (a) It aims to meet the individual and social needs of the citizen.
- (b) It opposes the science teaching of today in that the latter selects the few and does not develop the many, aiming at "Culture" instead of at citizenship.

(2) It is closely allied with the teachings of modern psychology.

- (a) It aims at "learning from experience".
- (b) It aims to employ content and method that have a high transfer value.
- (c) It upholds the psychological rather than the logical.

(3) In response to the above point of view the movement;

- (a) Disregards the traditional lines between the sciences.
- (b) Concerns itself with interpreting the environment in its broadest sense.
- (c) Glorifies the application, the invention, etc.
- (d) Attempts to give a broad attitude toward life by instilling a love for nature.
- (e) Considers specialized "research" science as the upper limit of a line of growth of which line in itself forms the lower limit.

C. A project is charactarized by:

(1) A desire to understand the meaning and use of some fact, phenomena or experience.

(2) A conviction that it is worth-while and possible to secure an understanding of the thing in question.

(3) The gathering from experience, books and experiments of the needed information and the application of this information to answer the question in hand.

D. Dewey's tests for projects.

(1) Is it real, vital—or is it formal?

(2) Is there anything but a problem? Does it arouse experimentation outside of school?

(3) Does it come from within, or is it imposed from without.

(4) Does the student have the necessary background for solving the problem?

(5) Is its difficulty proportionate to the ability of the student.

E. A project vs. a topic.

(1) A project originates in some question and not in such a logical sequence of ideas as may be found in codified subject matter.

(2) A project involves active and motivated participation of the pupil. A topic lends itself to formal treatment in which the teacher does all the thinking.

(3) Projects furnish a basis for the selection of facts according to value or significance. Topics do not.

(4) A project seldom ends in a complete final or absolutely finished conclusion.

Two Conflicting Views.

F. The various laws and phenomena of nature worked out as projects should not be worked out as a course of study.

(1) The projects would become topics.

(2) It is impossible to organize the problems of life.

(3) Projects must vary with every community.

(4) Our good "sample projects" are good only where they originate.

(5) Organization leads to standardization.

  (a) Standardization ties the good teacher's hands.

  (b) It does not aid the poor one materially.

(6) A great quantity of sample projects is the felt need of all

teachers in lieu of an organized course of study.

G. Projects should be organized into a course of study.

(1) Random projects lack unity.

(2) Without organization we lose the disciplinary value of project study.

(3) Without organization we cannot instill the broader attitude toward life which science can give.

(4) Without an organized course of study class room procedure tends towards inefficiency.

(5) The doctrine that "problems should originate from within" is limited to the extent that there already exists a scientific environment around the child which must be interpreted.

(6) These necessary elements (minimum essentials) problematized and then organized can constitute the course of study.

(7) A course of study does not necessarily mean a slavish adherance to it.

For a year the science work at the Speyer School was a series of projects—group projects, with the teacher taking the leading part. Each project was entirely unrelated to the next one, and in each case the class as a whole dealt with the same problem. In actual procedure the "group project" differed very little from the usual lecture or class demonstration. The problem may have been suggested by the pupils; but the teacher gathered the material, the teacher organized it, the teacher prepared the apparatus, the teacher performed the experiments—in fact the teacher did the thinking. Whatever, justification in theory that we had for our freedom in choice of material, was not at all sufficient after a years work with the "group project", in making us satisfied with our results. To have a whole group on the same project restricts the project. Conditions are unnatural. The pupils are too numerous. They must be kept quiet and restrained, or the discipline will be such as to neutralize all your efforts. There isn't anything which more than a project creates and fosters a restless spirit in the class. Everybody is up on his toes and wanting to relate personal experiences, give advice and ask questions; and although in a sense no one can call this disorder, it renders the teacher inefficient, unless he is willing to suppress some of the enthusiasm and ignore some of the questions.

To avoid these draw-backs and to carry out more fully the intent of the project science work, the second year, was developed

along two lines which I shall now try to set forth in detail. First, is what may be termed the "individual project" as distinguished from the group project; and second is the utilization of club work and other extra-curricular activities in teaching science.

First as to the individual project—The primary aim is to get every boy in the class working on a problem which will be entirely his own. In choosing the problem we struck a sort of compromise between the individual interests and desires (this received of course the most consideration) and certain general ideas of the teacher concerning the purpose of the course and its organization. With the latter I shall deal more fully later on. Each boy being provided with a subject in which he is interested, which is worth-while, and which is suited to his ability, work commences. In his work he is guided as follows: First it is announced to the class that on Nov. 12th, three or four weeks hence, George Richter is to have a period in which he is to lecture to the rest of the class on the submarine. And that George wants now to find out what the class would like to know most about the submarine. From the horde of volunteers, including George himself, we finally crystallize the following as an outline:

1. Who invented the submarine? When? How was it developed?
2. How can it submerge and emerge?
3. How is it driven?
4. How does the crew breath?
5. How does the crew live?
6. How does it see and steer?
7. How does it attack and defend?
8. What special dangers does it run?
9. To what uses can submarines be put after the war?

With that much to start on, George gets busy and for three weeks or more, he gathers material from books, magazines, newspapers and pamphlets. About once a week he holds a five or ten minute conference with the teacher who helps him across the hard parts. He writes to firms for interesting pamphlets, pictures and diagrams, he writes to the public library for their set of lantern slides and carries out numerous little experiments at home and at school, dealing with the principle of the submarine. These experiments are suggested by himself, the teacher, or the books, magazines, etc. which he reads. A few days before the date set, he posts a list of

about fifteen questions on the class bulletin board, which questions cover all of importance that he is going to say about his subject. This list which the teacher of course inspects, the whole class copies into their note books. When the day for the lecture arrives, each boy has the set of questions before him and is expected to answer the questions after listening to the speaker. The latter stands at the head of the class—the master of ceremonies. He performs experiments, shows charts, uses the black board, operates the projection lantern, asks questions and grants the privilege of speaking to the other members of the class. The most mediocre and nervous of boys, when full of information on his subject, and possessing the feeling that he is considered by all the authority will handle himself and the class in a most effective manner. The teacher sits in the rear, and is usually lost in the back ground. He is there to guide and direct when necessary, and to curb every now and then the rapid fire of questions at the lecturer by the class. The participation is always universal. After almost a year's trial of this form of "socialized recitation" I look back on some of the most pleasant hours of my life. If for no other reason, I recommend it to teachers as a relief from the nervous strain of the class-room.

With group one of the school, the best group, I have obtained results which I can charactarize by no other term than remarkable and even in the poorest groups, I have obtained advantages that made the scheme worth-while. In the poorer groups, I found it very helpful to keep constantly before the boys a series of questions which I called instructions for lecturers. By the end of the term these instructions had become a sort of constitution for class room procedure. They read as follows:

Instructions for Lectures

In preparing for your lecture, ask yourself or do the following:—

1. What is my subject?
2. What are the 3, 4, 5, or 6 most important facts I wish to bring to the attention of the class?
3. What is the best order in which to present them?
4. Under each of these big topics, what are the details that belong to them, and which do you plan to present?
5. Omit those which are unimportant.
6. Don't repeat yourself. It wastes time.
7. Are there any facts or ideas that you can explain better by means of a diagram?

8. Are there any facts or ideas that you can explain better by means of a picture or pamphlet?
9. Can you profitably use lantern slides? Can you get them?
10. Do you need specimens? Can you get them?
11. Are there any facts or ideas that you can explain better by means of an experiment?
12. If so, how long will the experiment take?
13. Is it worth the time? Is it worth the effort? It it possible to get the apparatus?
14. Can you work it before the class?

Remember that:

1. In one hour you cannot tell all you know about your subject.
2. The boys in your class have not studied the subject yet.
3. The boys in your class must be made ready to understand
4. Everything you say must have some bearing on what you what you say.
   are trying to explain.
5. If you have any conclusions, you must drive them home by making clear to everybody what they are. If you haven't any conclusions you must find them.
6. You must watch the clock as you speak.
7. Your classmates have no right to side-track you on other subjects.
8. Your classmates have a right to ask about things which are "in order."
9. Your questions must be clear and definite.
10. If you don't finish on time it is your own fault.

With few exceptions, the class hours were taken up with these lectures, each boy being given a date. The exceptional periods were devoted to review, summary and examination. At the end of one term of such work, each of our two hundred and fifty boys, under the care of two teachers, who spent on the average fifteen hours a week each at the school, has had at least one turn to lecture, has worked on at least two projects, and has answered correctly in his note book twenty-four sets of questions.

So much for the "individual projects" and the "socialized recitation." Both have disadvantages, and in both we run certain dangers; but neither the disadvantages nor the dangers are of such a nature, as to be without remedy, nor as to neutralize the good

which is involved. But by itself the problem of method, even when most satisfactorily solved, does not remove all the obstacles in teaching science. The question of content, of subject matter, of course of study, remains. Where are we to draw our projects from? To put it entirely up to the particular boy's interest, means very often to cater to a mere whim or fancy. There is no guarantee that the interest is a real one. Frank for example wants tremendously to lecture on acetylene gas because while going to school this morning he found a pamphlet advertising it. And Harry wants to lecture on the planets because his brother has a book on astronomy. What is more, like with any other human group, we usually find those that flit from one thing to another, those who specialize intensively, those who jump to the speculative questions, such as evolution, the ether and molecular theory, and of course those who don't seem to have any capacity for interest in science. It became essential, therefore, for the teacher to guide and control the content of work.

Prof. Briggs has set those two theses for the entire school and for all subjects. "It is our business in the school" he says, "First, to teach pupils to do those things better which they will do anyhow. And second, to open up for the pupil certain higher activities, make these activities possible and to some extent desired." For science, that means three things;

1. We must find out what is the modern scientific environment in which our boy is soon to find himself. And we must interpret this environment.
2. We must find out what elements of the scientific spirit and attitude function in life. And we must interpret that.
3. We must explore the fields of science and give ample nourishment to whatever embryo Newton's, Faraday's and Edison's that we may have.

I confess that stating our aims in this fashion does not answer the question; yet it does indicate a possible solution. From the very nature of the task this solution will vary widely. It will vary with locality, with the individual, with the occupation, with the age, and with several other factors. At the Speyer School it took the following form.

The general organization of the school issued a Speyer Creed which every Speyer boy lived up to and almost worshipped. Ac-

cording to that creed, a Speyer boy was trustworthy, a Speyer boy was loyal, a Speyer boy was helpful, a Speyer boy was respectful, honest, etc. etc. I insisted, and won my point, that a Speyer boy is also intelligent, and that a Speyer boy is also handy. And so two new laws were added to the Speyer Creed which represented the science in our school life. I shall take the time to read these two laws, because it served as my course of study—the source of the projects for the boys.

TWO ADDITIONS TO THE SPEYER CREED.

11. A Speyer boy is intelligent.

(a) He is an intelligent reader of newspapers for he knows a good deal about:

1. Aeroplanes and Zeppelins.
2. Submarine.
3. Guns and explosives.
4. Wireless.
5. Liquid fire.
6. Periscope.
7. Camouflage.
8. British Tanks.
9. Life Preservers.
10. Irrigation.
11. Radium.
12. X-Ray.
13. Perpetual motion.
14. Gyroscope.
15. Earthquakes.
16. Volcanoes.
17. Eclipses.
18. Coal mines
19. Weather prediction
20. Telegraph.

(b) He is an intelligent member of his family for at home he knows a good deal about:

1. The clothing he wears.
2. The food he eats.
3. Soaps, pastes and powders.
4. The piano and victrola.
5. Electric light and gas mantle.
6. Oil, gas, and electric stoves.
7. Radiators and ventilators.
8. Vacuum Cleaner.
9. Thermos Bottles and Fireless Cooker.
10. Bells and push buttons.
11. How to read the gas and watt meters.
12. Where to hang mirrors.
13. Seltzer siphons.
14. Matches and candles.
15. Clocks and watches.
16. Hot and cold water supply.
17. Antiseptics.
18. Food preservatives.

(c) He is intelligent when walking or playing on the street, for he knows a good deal about:

1. Fire Engines.
2. Automobiles.
3. Street cars and trains.
4. Telephones.
5. Elevators.
6. Electric signs.
7. Arc and Nitrogen Lamps.
8. Moving pictures.
9. Steam roller.
10. Fire Hydrants.
11. Sewers.
12. Cranes and Derricks.

(d) He is an intelligent member of his school for he knows a good deal about:

1. The pulleys in the gym.
2. The basket ball pump.
3. Tuning fork in the music room.
4. Thermostats, thermometers and ventilating registers in each room.
5. The furnace and boiler in the engine room.
6. The fire extinguisher in the hall.
7. The alarm bell system in the building.
8. Projection lantern in assembly.
9. The grindstone and motor in the shop.
10. Apparatus in the science room.

(e) He is intelligent when going on his vacation, for he knows a good deal about:

1. Field and forest.
2. Bird and Beast.
3. Flower and insect
4. Sun and moon.
5. Stars and planets.
6. The milky way.
7. The rainbow.
8. The use of the camera.
9. Farming and woodcraft.
10. Waterfalls and waterpower.
11. The cream-separator.
12. The tides.

12. A Speyer boy is handy.

He is quick of eye and nimble of hand. Here are some of the things which a Speyer boy can do:—

(1) Repair his bicycle and skates.
(2) Regulate the clock in the house.
(3) Fix the radiator so that it does not hiss steam.
(4) Tighten a gas valve so that it does not leak gas.
(5) Tighten a water faucet so that it does not leak water.
(6) Wire up or repair a push button, bell or light switch.
(7) Adjust a gas mantle so that it can last long and give good light.
(8) Pump up a basketball in the gymnasium.
(9) Wire up a desk lamp.
(10) Repair a gas stove.
(11) Regulate and take care of a player piano or Victrola.
(12) Replace a burnt out electric socket.
(13) Repair a small electric motor.
(14) Run the assembly lantern slide machine.
(15) Make a periscope.
(16) Make a pin-hole camera.
(17) Calculate the gas, water and electricity bills by consulting the various meters.
(18) Make a temporary and permanent magnet.
(19) Connect batteries and storage batteries.
(20) Repair a lock.
(21) Build a toy aeroplane.
(22) Run an automobile.

This is a rather formidable array of subject matter—but if the idea be kept in mind that in the junior high school we should survey each project in a general fashion, hitting the high spots so to speak, such a course of study can be easily completed in the

seventh and eighth grades, giving science two hours a week. Of course, depending upon the locality and particular needs, the "course" if we may call it that, will be stressed differently, amplified, changed or reduced. I am thoroughly convinced though, that after all the adjustments to various conditions have been made, there will remain an irreducable minimum common to all communities of modern life. Experiment only can definitely determine these "minimum essentials" in science.

I stated before that the science work at the Speyer School developed along another line, quite apart from class work and a line which I consider juite as significant. What I have reference to is the Speyer Science Club.

It seems to me that with the changing conception of the school and school house, with the many and varied socializing agencies within the school unit, that accompany this conception, the school, as never before, becomes a living force in the life of the pupil. The Speyer School became that kind of a potent influence. It was decidedly up to each subject to contribute to this social force or be snowed under. It was up to us in science to introduce a scientific culture into the little Speyer community after school hours, or be considered in a class with the other school drudgeries. And so there arose this Club with its constitution, set of officers and nearly seventy-five members. To be a *grade A science club member* meant to be one of a group of twenty picked boys who received A in science every month and who devoted all their extra curricular time to science. These twenty, under the teacher's guidance, became the masters of the school environment. They were known and recognized all over the school by their green and white S S C arm bands which they religiously wore. They were called upon by teachers to regulate radiators, clocks, ventilators, and ventilation. They fixed the water faucets, electric switches and sockets. They were on good terms with the janitor and had access to the boiler room. They operated the assembly projection lantern and the school Victrola and player piano. They actually repaired the school fire alarm bell system when the janitor gave it up as a bad job. They installed a bell system in the school which announced the ends of periods, and also a complete home-made telephone sytsem from office to gym, to science room. To be a *grade B science club member* meant to be one of a group of about fifty boys, who either because of their inability to get A in science each month, or

because of other school activities, could not completely devote themselves to such work. These boys attended meetings, were given the privilege of listening to prominent outside lecturers who visited the club, were invited to attend our trips to large industrial plants, and were expected to make some contribution to the work of the club.

The club held scientific initiation ceremonies for new members. It assigned tasks to applicants such as reconstructing a small electric motor, given its seventy-five odd parts all jumbled up in an envelop. It took over some of the school assemblies and gave an exhibition of its work together with several scientific tableaux. It ran a Scientific Grab Bag and raised a sum of money for which to purchase the Book of Knowledge. It had its meetings announced by means of large electric signs. And it played a prominent role in the columns of the school paper. One particular group of these boys, altruistically inclined, decided to call themselves the Scientific Helpers with the idea of aiding some of the boys in the school who found special difficulty with their lectures for class work. They made a list of all possible projects and laboriously went through our library of more than two hundred books, as well as numerous periodicals and listed the page, etc. where information could be found on each project—adding hints and suggestions. These they filed away in an index cabinet. They are still at work and I hope to have a rather valuable organization of material as a result. It is needless to discuss the value to these boys, of such work. I might also add that our library was entirely in the care of the boys themselves, there being a librarian present each afternoon of the week to distribute books and give aid. The teacher's part in all this was very difficult and exacting only in the beginning. Once organized, the boys almost forced the teacher to retire.

Originally I organized this group to combat the apathy which existed towards the science class and things scientific in general. It seemed entirely contrary to the supposed interests of boys that there should be a flourishing Latin Club in the school, among other things, and no interest in science. As the science club developed and changed apathy to enthusiasm, I found myself dealing with quite a different problem, namely: the problem of laboratory work in general science. I believe, that as yet no one has proposed laboratory work in this field for we have been quite satisfied

to reserve the laboratory for the more formal study of the various sciences; partly because general science has been so uncertain, and partly, I suppose, because of the unwillingness to double an already difficult problem. But as the movement increases in force, that phase of the work is beginning to demand more serious consideration. I feel that in the work of the Speyer Science Club a few suggestions may be found. For example, at its annual exhibition, the club exhibited more than sixty pieces of apparatus, scientific toys, etc., which they themselves made at home, in school, or in the shop. The results were rather crude, but interesting and what is of greatest importance, workable. I cannot do better than to submit a list of the more important of these bits of apparatus.

There was first a telephone receiver and transmitter set made from an iron rod, a spool and a tin can. It worked admirably. There was also a box camera, made from a card-board box and a cheap convex lens. We took a fairly good picture of the class with it, the boys doing the printing and developing in our closet fixed up as a dark room. Then there was a fire-extinguisher made from two bottles and a piece of rubber tubing; and lantern slides that made announcements to the school in the assembly; and some very tiny motors made from an iron nail, some wire and a horse-shoe magnet.

On a small scale, we had a water wheel that drove a miniature power plant with faucet water pressure, a periscope, several submarines, a telescope, a steam-engine model, a storage battery, a wet cell, a dry cell, an electric bell, an ingenious reversing switch, a thermo-meter, a pump, an induction coil, a fireless cooker, an ammeter and voltmeter calibrated to read fairly accurately, magnetic compasses, telegraph sounders, a small projection lantern, a reflectoscope, an immersion heater, a variable rheostat, an aeroplane model, a transformer, a spectroscope, and an electric lamp.

In connection with the above several of the boys went through the entire Gilbert and Zeno Chemical Outfits. For those who are unfamiliar with these "Outfits" I shall submit parts of the Table of Contents of one of these Outfits.

PARTS FROM THE TABLE OF CONTENTS OF GILBERT'S CHEMICAL OUTFIT

How to coat an object with nickel or copper.
How to make a duplicate of your medal.
How to etch electrically on copper.

How to etch upon steel.
How to petrify the baby's shoe.
The lemon electric cell.
Make your plaster cast into metal.
Plating by simple immersion.
Beauutifully colored precipitates with phenolthalein.
Testing for metals by the flame colors.
How to make ammonia.
How to fireproof cloth and wood.
Making chemical soap bubbles.
Inserting an egg into a bottle by softening the shell.
How to start a fire chemically.
Making frosted glass.
How rock candy is made.
Make your own ink.
Disappearing ink and why it disappears.
Making illuminating gas.
How to make an acid from wood.
How charcoal is made.
How diamonds are made.
How to make your own soap.
Manufacture of soap powder and shaving cream.
How glass is made.
etc. etc. etc.
A magic program and magic tricks.

In all of the above our material was either supplied by the boys themselves, was reclaimed from the Teachers College Junk Room or it was bought with the ten dollars which the General Organization of the school gave us. I feel that I can very safely say, that given a laboratory manual, written along the lines of the Gilbert Chemical outfit (minus the cheap advertising features and perhaps the appeal to the sensational) and given also about $75. to $100.—and a type of laboratory work for general science can be introduced which will enrichen and make possible the highest type of project teaching. That and the use of the school building as a laboratory are two ideas which our work with the science Club has proven to be highly practicable.

One further fact did our work of the past year crystallize into a need which I feel must soon be met. We must have a suitable text. I realize that I am treading on dangerous ground. I realize that the formalizing influence of a text may destroy whatever good has been accomplished by the project idea. But I cannot help feel that a text can be written that shall guide and suggest and not hinder—that shall provide suitable sources and definite work-

able material that experience has proven to be of value. I will venture a series of requirements for a text, that would be of immense value to me. Let other teachers do the same. Is there not the possibility that in this manner we may develop such a book? In my text book I want to find:

(1) The "minimum essentials" of science worked out on some such plan as I have previously discussed.

(2) With each "essential" I should like to find:

- (a) A biographical sketch of the inventor.
- (b) A brief history of the developement.
- (c) An explanation that will lead to an understanding and appreciation.
- (d) Clear and simple diagrams and pictures.

(3) An interesting manner (with apparatus etc.) of presenting each particular essential to a class.

(4) A list of simple constructional exercises and experiments with instructions as to how pupils can perform them, including place of purchase and price.

(5) A rather extensive bibliography of material that boys can read and appreciate. This ought to include fiction.

(6) A set of leading questions with each "essential".

(7) A "cultural transmission" which will use each of the "essentials" as a means of leading those who are capable of it onward to "research" science, or high appreciative and theoretical science.

And together with the text should be the laboratory manual of which I spoke before—that collection of material to be found in Morgan's Boy Electrician or Woodhull's Work and Play series or the Chemical Outfit or the various other construction manuals for boys.

In conclusion let me summarize what I have been at such length in saying, for fear that I have perhaps been rather disorganized in my presentation.

(1) The war is demanding a change.
(2) The Junior High School is our opportunity for change.
(3) The PROJECT METHOD is the most significant change in educational method.
(4) The project idea finds fertile soil in science teaching.
(5) The Group Project does not solve the problem.
(6) The Individual Project combined with a socialized form

of recitation, offers certain very valuable advantages, and is more in keeping with the project spirit.

(7) A Course of Study of Minimum Essentials is a possibility that is not incompatible with the project idea. (Speyer Creed.)

(8) It is absolutely essential that we utilize the social nature of the boy and make each and every subject a part of the real life of the school. (Speyer Club)

(9) And finally there is a demand for a different type of laboratory work and a different kind of text book—which will guide without restricting and help materially in the process of increasing our crop of scientific specialists—while at the same time we produce a citizenship of men and women really appreciative and intelligent in judging the affairs of life.

What Eighty Teachers Think as to the Aims and Subject Matter of General Science

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General science has now attained some years of age, and a surprising degree of recognition in our high schools. Her friends and champions are many, and yet, in some quarters this new member of the secondary science family is treated with suspicion and contempt. In some schools, the other members of the teaching staff, while admitting the need and possible value of such a course, have little but honest scorn for the wondrous conglomeration presented under that name in their school. A fad they term it—general enough in truth, but unworthy the name of science.

Allowing for traditional conservatism or inertia, and for jealous rivalry, it has seemed to some of us who have advanced from this attitude to one of appreciation and optimism, that no small part of this hostile skepticism, this questionable repute, is due to the nondescript and chaotic status of this subject. What is general science, anyway, asks the caviling critic, and who can answer? What can be expected in later special science courses from those who have had a year of general science? What weight should a credit in general science carry in case of transfer to another school? Who knows—a careful survey of the texts available

reveals an almost grotesque variation as to selection of material, relative emphasis, and omissions. And as if this were not enough, almost every young teacher with a year or so of experience essays the development of a brand new, original, and wonderful course—a notebook or text. A sign of vigor you say—but perhaps also one of peril.

For general science is, in a way, on trial. Her future is at stake. Is it to be a course of extremes and faddism, of pretence, shallowness, and superficiality, protected by excess of freedom? The writer believes that the time is ripe for the mass of sane but liberal science teachers who are engaged in this work to insist on, and cooperate in, an evolution of some definite standards to guide, in the planning and judging of general science courses. This need not mean iron clad syllabi, with a checking of individuality and adaptation, but it should mean first, an honest and serious attempt to answer two questions on which depend the reputation and the future of this subject.

The two questions are simple. Why are we teaching general science —why is such a course needed—a clear statement of dominant aims. And then—what are we teaching—what should we teach—a definition of content, and in a tentative way, of minimum essentials. On the first question, that of aims, many opinions have been voiced, in the prefaces to texts and in periodicals, with a hopeful tendency toward agreement. But on the question of content, agreement would seem almost hopeless. An attempt to frame a tentative syllabus by a group of teachers in a city system is likely to precipitate war for two big reasons, violent championship of some "one and only" notebook course, or cherished text, and no less militant prejucice because of previous condition of servitude. Our botanist knows botany and must feature it, the chemist is just as sure of his ground, and the former physiographer must make his stock in trade the center of operation. Do not our texts, with few exceptions show the effects of such biases?

And yet, there is a sincere cry for help. The beginner in teaching, the overworked victim of too many subjects, or too full a program, the candid but finite specialist in science—anyone of these, called upon to present a course in general science to a hundred or more children— will need and demand aid and guidance. What are my aims to be, just what shall I teach, what text or texts shall I use, how can I presume to choose and eliminate wisely in the

presence of such a wealth of material? The only reliable point of departure in answering these appeals is clearly scientific study of the facts. It is not safe to follow the advice or plans of some one prophet with his panacea. Let us rather apply our vaunted scientific method to the experience and judgment of hundreds of teachers, and so discover some safe common ground as a foundation on which to build. Such is the attempt of the present study—may it be but a beginning.

It seemed, in view of the character of the problems and the absolute need for cooperation, that the questionnaire method, with all its shortcomings, was the only one possible. Accordingly a questionnaire was framed, intended to shed light on the questions already outlined. After criticism by a group of Cincinnati science teachers, a final draft was prepared. This formidable missive was sent to 150 teachers of general science about March 1. The mailing list was obtained thru the kindness of the Editor of General Science Quarterly. In selecting names from a larger number, two criteria were applied, first, a desire to obtain the widest possible geographical distribution, and second, to include mainly teachers in larger towns and cities. The latter limitation was due to a selfish desire to make the results more directly applicable to our Cincinnati problems, and must be kept in mind. In sending out these letters the writer acknowledges the support and aid of Dr. Hall-Quest and the School of Education of University of Cincinnati, and also of the commercial department of Hughes High School. The questionnaire in its final form is here printed in full.

General Science Questionnaire

1. Aims of General Science.

Please number, in order of their relative importance to you, the following commonly expressed aims of General Science. (write 1 in front of most important, 2 in front of next, please try to rank entire list as best you can.) Aims — General science in the first years of high school should give each pupil—

(a) A fund of valuable *information* about nature and science.

(b) The greatest possible understanding, appreciation and control of his everyday environment.

(c) *Preparation* and foundation for the later study of special sciences.

(d) Appreciation of the *applications* of science in modern industrial and social life.

(e) Training in the use of the *scientific method* in solving vital problems.

(f) A *vocational* survey of the sciences to guide and inspire plans for life work.

(g) *Interest* and motivation to vitalize his work and prevent his elimination.

(h) *Appreciation* of the unity and beauty of science, and of the work of its master minds.

(i) Training in cold, scientific thinking, carried on with strict self elimination. (Coulter)

2. Content—Selection of Topics.

Please mark each of the following topics which you consider *fundamental* to a high school course with the letter F, (preceding), and mark any others which you have tried and found successful as *supplementary* material with the letter S. If you have still other favored topics, write them below, lettered F or S. All these topics are, of course, to be treated in an elementary and popular way and adapted to the needs of the class.

LIST OF TOPICS

Systems of Measurement.
Force, power, and energy.
Molecular theory of matter.
Simple machines and law of work.
Air—chemical composition and combustion.
Air—physical properties.
Water—chemical properties.
Water—physical properties and mechanics of liquids—pumps.
Water supply and purification.
Household heating and lighting.
Ventilation.
Theory and laws of heat.
Light—nature and relation to life.
Sound—nature and relation to life.
Modern electricity and magnetism.
Coal, gas, and petroleum.
Combustion and fuels.
Density, specific gravity, and buoyancy.
Plumbing and household appliances.
Steam and gas engines.
Elements of physiology.
Foods—diet and digestion.
Hygiene and sanitation.
Clothing and textiles.

Everyday chemistry—salt, ammonia, nitrogen, carbon, carbon dioxide, fertilizers, paints, drugs, photography, etc.
Household chemistry—baking powder, fermentation, stain dies, flavors and extract, etc.
Elements, compounds, and mixtures.
Acids, bases, and salts.
Cooking and baking.
Iron, steel and other metals.
Drugs, narcotics, and alcohol.
Plant life and forms—elemmen. botany.
Animal life and forms—elem. zoology.
Bacteria, yeasts, and molds.
Evolution and heredity.
Common birds.
Trees and flowers.
Weather and climate.
Astronomy and the stars.
Physiography.
Soils and rocks.
Agriculture as applied science.
Gardening.
Cost of living—reasons.
Fireproofing and waterproofing—fire prevention.
Time and its measurement.
Transportation and railroads.

3. Special Problems of General Science.

A. Please check that method of instruction below which you have found most satisfactory, in use.

(a) Textbook—Assignments and recitations, based on one special book, chosen as text.

(b) Reference—Assignment, study and comparison of material in a number of texts or reference books, using notebook as supplement.

(c) Notebook—Basing course chiefly on careful development of topics in a full notebook in which are recorded results of class discussion and experiment, and of reading.

(d) Project—A grouping of the study around certain large but simple practical problems, in solving which the study of science is involved incidentally. (Twiss)

B. Please list here a few vital "projects", which you have found adequate and effective. (Space provided.)

C. Check below *your* commonest methods of using experiments.
Demonstrations by Teacher. Demonstrations by Pupils.
Individual or small group experiments—Inductive or leading to discovery of truth.

Individual or small group experiments—Deductive for proof or illustration of principles stated.

D. Name your preferred text in general science.
   How many texts have you reviewed carefully?

E. Do you use supervised study?
   If so, by what general plan? Check!
   Alternate period, divided period, conference.

The returns were all in by the end of March, and it is very creditable to the spirit of the teachers selected, that replies to the number of 80 were received—over 50%. These returns were from 24 states in all, with Ohio and Massachusetts leading. They were distributed rather broadly, as follows—30 from the eastern states, 29 from the central states, 14 from west of the Mississippi, even to California and Oregon, and 5 from the southern states. With such an encouraging amount of material from such broad sources, it seems worth while to offer the results of the study as a tentative, initial attack on some vital problems of general science. The conclusions do not represent an individual opinion, we have had a surfeit of such evidence, but give us the more practical and reliable composite judgment of eighty teachers of actual experience. Taking up the first division, (1), let us examine this composite evidence as to aims. Why do we teach general science, or what should be the contribution of such a course to the life and development of a young secondary pupil? In my list, an attempt was made to analyze the aims most commonly expressed into distinct elements and so get a clear reaction as to their relative importance. The table of rankings and scores is given below.

In table I. page 451, the aims are arranged and numbered in order of their final ranking, and the first nine columns give the frequencies, or the number of teachers placing each aim in any given rank. An explanation of the total score in the last column is needed. It was obtained by multiplying the number of persons placing that aim in each rank by the number of the rank, and adding these products. As an example, for Aim (b)—Total Score=(53x1)+(10x2)+(7x3)+(2x4)+(4x5)+(3x6)+(1x9) =149. A moment's thought will convince, that whichever aim tends uniformly to obtain rank highest in the list, i. e. nearest first rank (1) will have the *smallest* score, and so on down the line. So the scores in last column are in ascending order, and the aims are in exact order of importance to this group. Should this method

AIM OF GENERAL SCIENCE—As Ranked by Eighty Teachers.*

The Aim of General Science is to give each child	RANK—as given in 80 Questionnaires 1	2	3	4	5	6	7	8	9	Total Score
1. Understanding, appreciation, and control of his everyday *Environment*, (b)	53	10	7	2	4	3	..	..	1	149
2. Appreciation of the *Applications* of science in industrial and social life, (d)	5	23	15	17	11	2	5	2	..	282
3. A Fund of valuable *Information* about nature and sciences, (a)	12	13	13	17	10	7	4	3	1	293
4. Training in use of the *Scientific Method* in solving problems, (e)	8	11	12	14	7	7	11	9	1	357
5. *Preparation* and foundation for later study of special sciences, (c)	6	6	10	11	14	8	12	11	2	400
6. *Interest* and motivation in school work to prevent his elimination, (g)	1	10	12	9	10	15	13	8	2	406
7. A *Vocational* survey of sciences to guide and inspire life work, (f)	1	7	9	8	17	16	13	6	3	421
8. *Appreciation* of the unity and beauty of science and of its master minds, (h)	1	2	5	5	10	16	11	27	3	506
9. Training in cold, scientific thinking involving self elimination, (i)	1	3	5	4	3	2	4	6	52	609

*Some teachers insisted on ranking the aims by groups, rather than in order from first to ninth. For example, one would mark several aims, such as (b), (d,) and (a), all *first*, (1), another group (2), and the rest all (3), etc. Such irregular scoring causes some of the ranks to total vertically slightly more than 80, and others less than 80, but does not at all affect the validity of the comparison.

seem unduly artificial, note that the aims ranked 1, 2, 4, 5, 6, 8, and 9, also show modal frequencies in their respective ranks—(b) is ranked first by 53 out of 80, (d) second by 23, and (i) last by 52 out of 80.

There were complaints of the difficulty of ranking *all* the aims, as requested, and some attempts required careful scoring. In fact, our natural and proper tendency is to combine certain of these aims, but for comparison and objective ranking some such method as the one used was necessary. Let us sum up, and combine results as indicated by the data. The primary and basic aims of general science in our high schools are to give each pupil the greatest possible understanding, appreciation, and control of his everyday *environment*—next, to acquaint him with some of the industrial and social *applications* of science—and to furnish as wide a fund of *information* about nature and science as time permits. Our watchwords seem to be—everyday environment first, then applied science, and information third.

Now for the troubled question of content. The marking of the list of topics as *fundamental,* (F), or *supplementary*, (S), led to a scoring of each topic as to the number of teachers who consider it fundamental, and the number who have rather found it useful as supplementary material. From a careful study of these scores, the following lists have been prepared. In the tentative list of fundamentals, all topics are placed which were marked F by a majority, or over forty, of those answering, while in the supplementary list are all topics, scored either F or S by over fifty out of eighty teachers. In both lists the topics are ranged in apparent order of importance and the scores are given in case other use could be made of the data.

List 1.—Fundamental Topics, or Minimum Essentials, of General Science.

	Scores—	F.	S.
1.	Water—physical properties and mechanics of liquids.	73	4
2.	Air—chemical composition, and combustion.	71	6
3.	Air—physical properties and mechanics of gases.	69	7
4.	Ventilation.	63	15
5.	Household heat and light.	62	15
6.	Water supply and purification.	60	15
7.	Weather and climate.	59	15
8.	Bacteria, yeasts, and molds.	58	10
9.	Foods—diet and digestion.	57	9

10.	Combustion and fuels.	56	16
11.	Hygiene and sanitation.	55	9
12.	Water—chemical properties.	55	17
13.	Plant life—elementary botany.	50	9
14.	Everyday chemistry (salt, ammonia, carbon, etc.)	49	19
15.	Simple machines.	48	13
16.	Force, power, and energy.	47	11
17.	Animal life—elementary zoology.	46	12
18.	Systems of measurement.	43	21
19.	Acids, bases, and salts.	43	21
20.	Elements, compounds, and mixtures.	42	20
21.	Density, specific gravity, and buoyancy.	42	18
22.	Electricity and magnetism.	41	25

LIST 2.—SUPPLEMENTARY TOPICS—OPTIONAL MATERIAL.

	SCORES—	F.	S.	Total
1.	Household chemistry (soda, stains, etc.)	35	30	65
2.	Coal, gas, and petroleum.	39	25	64
3.	Molecular theory.	40	22	62
4.	Light and its relation to life.	40	20	60
5.	Astronomy and stars study.	23	37	60
6.	Soils and rocks.	37	22	59
7.	Steam and gas engines.	20	39	59
8.	Plumbing and household appliances.	32	26	58
9.	Sound and its relation to life.	26	30	56
10.	Cooking and baking.	23	33	56
11.	Elements of physiology.	40	15	55
12.	Iron, steel, and metals.	17	36	53
13.	Trees and flowers.	23	29	52
14.	Theory and laws of heat.	29	22	51
15.	Drugs, narcotics, and alcohol.	20	31	51

LIST 3.—REMAINING TOPICS—THE LEFTOVERS.

SCORES—	F.	S.	Total
Gardening.	24	26	50
Fireproofing, waterproofing, etc.	20	30	50
Clothing and textiles.	16	34	50
Cost of living.	23	26	49
Agriculture as applied science.	17	32	49
Common birds.	19	28	47
Physiography.	21	25	46
Time and its measurement.	16	29	45
Transportation and railroads.	12	33	45
Evolution and heredity.	20	23	43

One outstanding feature of these lists is their harmony with our aims—the emphasis on everyday environment, industrial or

social applications and information. Traditional and organized science lines are lost sight of in these selections.

The same and practical order of the lists and the remarkable tendency to agreement in the group at large, in spite of evident bias in some cases, are bases for hope that the results may be of value to some.

The form of the topics was criticized severely in a few cases, as being cut and dried and traditional, leading only to a "hodge podge" system of combining special science material. This seemed however the surest or only way of getting at the facts. These topics are not original, but are a result of very careful study of the subject matter in most of the late texts, and of other analyses of their contents, such as that of Prof. H. A. Webb. (School Science and Mathematics—June, 1917.) These lists are simply a means of selection of material and scope, and determination of emphasis, in the only way in which we can meet on common, familiar ground. Such lists do not imply or support any special method of instruction, and the topics are of course to be presented in that way which seems best suited to various classes or individuals. Least of all do they preclude project or problem approach. As one reply aptly stated, "A project is the *topic* transformed into a problem which appeals to and grips the pupils." It should often be so used. The proper sequence of topics and their organization into units of instruction and recitation, the division of time and selection of material or problems within topics, are problems beyond the scope of this paper, and perhaps best left to individual solution.

But of what use then, are these lists or similar ones which may later be evolved or endorsed? First, they may form one of the best bases for a needed agreement on tentative syllabi, as in our own city. Where individual opinions clash, here is a common impartial statistical criterion. Secondly, the lists may afford some help to the classes of teachers who, like the writer, feel the need of advice on such knotty problems. In the third place, they may be of help to principals and supervisors, as well as to teachers, for the evaluation and criticism of texts or proposed notebook courses. It would seem that books omitting any large number of the topics in our first list must bear the burden of proof. Last and of most importance would be a continuation of such cooperative collective study from this perhaps crude attempt to fuller and abler studies which might serve as a basis for a liberal but sane

organization of "first year science" on a foundation of actual general experience.

This might seem the end of our task, but the writer could not resist the temptation, when sending out these letters, to seek light on several other important problems which he has been facing. Their meaning is fairly obvious, but the results are not so conclusive. The data as to method of instruction are as follows. Reference back to Part 3 of the Questionnaire will supply the exact description of each method scored.

A. METHOD OF INSTRUCTION

(a)	Textbook Method—one special text	30
(b)	Reference Method—a number of books	9
(c)	Notebook Method—developement by notes	21
(d)	Project Method—grouped around large problems	23
	Combination of (a) and (c).	6

As might be expected, no single method seems to be universally used or endorsed. Many replies, tho not as many as one might expect, indicated wholesome combination of (a) and (c), (b) and (c), (b) and (d). etc., and we may agree readily with some writers that no one of these methods should suffice for all types of work. Without intruding an opinion as to (c), some notebooks I have known seem to warrant a warning against making a fine and copious notebook an end rather than a means. Remember our dominant aims, and subordinate method to those ends. Sometimes children must spend so much time writing that they have too little chance to think or talk, and take too much by dictation—fool's gold.

The fine showing of the project method, and the rampant enthusiasm of the replies of some of its exponents, were tested by the request to list a few favored projects. This call was answered by 35, so evidently some use projects as a secondary method. The lists of projects prepared from these answers would alone form the basis of a paper. They vary from good to bad, but can be roughly divided into two groups. About 15 showed by their lists of projects a realization of the significance of that method as advocated and illustrated by Woodhull, Barber, Twiss, et al. The other 20 at least did not present real projects and the implication is that they fail utterly to differentiate a project from a topic. A few examples from each group will illustrate fairly.

B. 1. Real Projects.
Making a fire extinguisher.
Making an electric bell.
Erection of 75 ft. flagpole.
How to build a fire.
How we save food from spoilage.
How is bread made?
A star project, launched by means of some special phenomenon.
The leaf as a factory.
Story of a lump of coal.
The story of my suit.
A pinch of salt.
Study of a match.
How are messages sent by telegraph?

2. Pseudo Projects—Topics in form.
Air—Composition, ventilation, and combustion.
Heat, its source and benefits.
Bacteria—disease, infection, etc.
Water supply.
Common machines.
To light our school.
Thermostat.
Illuminating gas.
Air.
Sanitation.
Weather.
Safety first.
Camera.
Soil.
Fuels.
Meters.

It seems as tho these lists, and the numerical showing, indicate, as do some of our best articles on the subject, that the project method of teaching is winning its way, and is of real value, but is still in process of slow evolution. It is scarcely a panacea for all ills, nor a safe exclusive method for an overworked teacher or a beginner.

Next comes the method of using experiments in general science. I append the table of scores.

C. TABLE FOR METHOD OF EXPERIMENTATION.

1. Demonstrations by Teacher. 63
2. Demonstrations by Pupils. 19
3. Individual or small group experiments
   inductive in form 36
4. Individual or small group experiments
   deductive in form-proof or illustration. 15

It is very probable that the use of one or other of these methods is often a matter of expediency—of time or room available and of limited equipment. Ideally, as some suggested, we should employ every one of these methods as found most effective for the purposes outlined before, but only as real means to those ends.

Many of the liberals who occupy a middle ground feel unwilling to abandon altogether the use of texts, even in general science. When they are the fruits of years of careful work and experience of able, practical school men, they are of inestimable value to the rank and file of ordinary teachers, as reference material, if not for exclusive use. Our great need in first year science, is an ideal text, based on a recognized foundation of aims and content, but it must be the result of experience and evolution, not of theory and enthusiasm alone. I give the list of texts mentioned as favorites without comment.

D. FAVORITE TEXTS—Hessler—13, Barber—11, Caldwell and Eikenberry—11, Clark—10, Elhuff—7, Snyder—4, Fall—2, Pease—2.

Many teachers indicated, one profanely, that they found none of the present texts satisfactory, which is not surprising in the absence of agreement on aims and content. At present, reference to several texts seems to be a common method, but the following figures show a deplorable failure to review fairly and thoroly a sufficient number of the books already available.

D. NUMBER OF TEXTS REVIEWED CAREFULLY.

1 Text —0	5 Texts— 6	9 Texts— 2
2 Texts—0	6 Texts—16	10 Texts— 9
3 Texts—5	7 Texts— 6	11 Texts— 1
4 Texts—3	8 Texts—10	All Texts—15

My last question was in regard to the use of supervised study, another symptom of progressivism. It seems a very natural means of introducing children to general science, especially in the co-

operative framing of projects and problems, and in experimenting. I surmise that many of our friends if they investigated the subject, would find they had been using study supervision, tho not distinguished by that name. I submit the data which are obvious.

E. DO YOU USE SUPERVISED STUDY. YES—38. NO—38.
General Plan of Study Supervision.
Divided Period—24, Conferences—10, Alternate Period—2.

In closing let me acknowledge my indebtedness, for inspiration, support, or aid, to Dr. A. H. Hall-Quest of University of Cincinnati, Dr. L. V. Roos of University of Washington, to the commercial department of Hughes High school, and to the editor of General Science Quarterly, but most of all to the eighty co-workers who answered a rather lengthy questionnaire.

A Remedy for the Congestion of Subject Matter in General Science.

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Listening not long ago to a debate carried on by teachers of English in high schools and colleges, I was struck by a similarity in the nature of the controversies which rent them and those disturbing the peace of laboratories of science. The fiercest battle raged about the question of the practical versus the ideal as legitimate aims in teaching. There were those among the disputants who apparently believed that no sordid details of material benefits to be derived should come between the mind of the student and the contemplation of "the best that has been thought and said" in the world's history. They referred to "business English" with the same air of disdain that the corresponding type of science teacher uses in speaking of "grease spot chemistry".

It is perhaps not difficult to comprehend this state of mind and to allow for it. The devotee of perfection of style has spent hours in the study of masterpieces of English and in the effort to approximate his own writing to their lofty standards, while the earnest seeker for scientific truth has schooled his mind to minute observation, precise measurement and strict application of logical process-

es. Holding these high ideals constantly in view in their own work and realizing so keenly the time and patience required to attain them, attempts to divert their energies into what seem to them meandering byways are naturally resented. Back of their reluctance, too, and less often coming to the light in public discussions, I can not help suspecting personal preference. Confronted with the task of instructing some dozens or hundreds of immature minds the extreme classicist, be he an instructor of English or science, feels that to be successful he must teach whole heartedly and with enthusiasm. Practical applications he loathes and therefore follows the path of least resistance and continues to direct the attention of his pupils to the "best that has been thought and said in literature and science. The more utilitarian minded realist may yield to the same temptation of following personal inclination and neglect entirely the broader or more abstract aspects of the subject he teaches. "Essay English" or "formula chemistry" fill him with impatience, therefore he avoids them.

Lifted beyond the region of personal inclination and recrimination, the question becomes, however, real and important to the present and future lives of school boys and girls. Is the movement now permeating all branches of education permanent? this movement towards a more constant, direct and intimate contract between—I was going to say real life and school life—but is seems absurd that school life should not be real and the question in the asking answers itself. Surely it is a movement that has come to stay and is bound to progress, not, as extremists would have us believe, one of the many fads and eccentricities which hamper human endeavor.

If, then, as we are told on all sides, the present duty of school masters and mistresses is more than ever to train boys and girls for a speedier efficiency and a more complete harmony with the keynote of modern progress, social service, it behooves us to sternly suppress private preferences and to survey the field with all the impartiality we can muster. As teachers of science we should ask ourselves,—What kind of science is at present taught? Is it fulfilling expectations? Are any modifications needed to make it more effective in the future? If so, in what direction should improvement be made? Do we need more emphasis on things practical or on mental discipline and abstraction? Is it possible profitably to combine the two? I have tried for my own purposes to find answers

to these questions and welcome the opportunity to lay the results of my inquiry before the readers of the GENERAL SCIENCE QUARTERLY hoping that some of them, from their experience, may be able either to reinforce or to correct my conclusions.

The science prevailingly taught is, as we all know, generally divided into such special subjects as physics, chemistry, biology (often subdivided into botany, zoology and physiology) and geography. In high schools, public and private, and in the colleges, laboratory work is the rule, often carried out by the students from printed directions and illustrative of certain scientific principles considered desirable for them to know. Many of the text books used open with a chapter in which fundamental conceptions are defined (matter, density, weight, elements, compounds, etc.), proceed in the following chapters to the explanation of certain laws involving these conceptions and give, either incidentallly or at the end of each chapter, illustrations of the applications of these laws,

Within the last few years, in response to the growing demand especially in manual training, trade and vocational schools, for a closer relation to actual life, text books and laboratory manuals have been appearing which subordinate principles and definitions and deal more directly with daily experience, but for general high school courses a modification of the method pursued in colleges is still the rule.

An attempt to answer the question as to whether this way of presenting the subject to high school students has met with success has been made by Elliot R. Downing in articles published in the General Science Quarterly for November, 1917, and in Science for October 12th, 1917. By means of figures taken from the Report of The United States Commissioner of Education, he shows that there has been a decrease, during the period 1910-1915, in the percentage of students taking the "old line subjects" in science which is not compensated for by the percentage taking more recently introduced subjects such as agriculture and domestic science and draws therefrom the conclusion that "it is fairly evident that the high school science course is in some way out of joint with the times." While this may in truth be the case, it does not necessarily follow from the figures of the United States Commissioner. In the year 1909-1910 the percentage of high school students enrolled in science was 91.99, in 1914-1915 is was 81.16. This does not of

course mean that fewer students were taking science in the latter year. On the contrary it means that more were, for during the period 1909-1914 the total high school enrollment increased 45.1%. For every 1000 students in high school during 1909-1910 there would be in 1914, 1451, therefore for every 920 pupils studying science in the former year there would be, in the latter year, approximately 1175. It does nevertheless mean that for approximately 276 out of every 1000 science is considered to be of little if any value. A possible explanation for this may lie in the fact that an increasing number of students are entering commercial courses and the time required for subjects more directly related to office practice and the making of a living by clerical work crowd out from the curriculum scientific subjects along with the classic languages and masterpieces of English literature.

Concerning the interest of the pupils themselves it is hardly fair to use these statistics as a test, since the opportunities for election of subjects in high school are extremely limited and often more apparent than real. The figures are more indicative of how far the makers of curricula consider science important. Perhaps more light may be thrown on the question of student interest if the proportion of students electing science in non-technical colleges is compared with the proportion election other subjects. If science courses in high school have made the subjects vital and have aroused the desire to know more about it the proportion continuing its study in college should be relatively high.

The necessary information is furnished by the investigations of Dr. Frederick C. Ferry of Williams College supplemented by those of W. LeConte Stevens of Washington and Lee University. (Science Oct. 24th, 1913 and Jan. 1st, 1914). Dr Ferry tabulated the registration of academic students taking various subjects in eighteen representative colleges and universities, coeducational as well as those exclusively for men or women. The subjects fell into three groups: I. Languages (classic and modern). II. Humanities (including English). III. Sciences (including mathematics). Reduced to "student hours of instruction" and calculated in percentages, Dr. Ferry's results were for the I. and III. groups respectively 24.50 and 28.72%, for Group II. 46.78%. Prof. Stevens, from these results, derived a value P expressing numerically the average demand for any given subject in the eighteen institutions. The average value of the sixteen subjects represented in

the table was a little over 6 which was therefore taken as a "rough standard for comparing the student demand for different subjects". This average was not reached by astronomy, Greek, geology, physics, Bible study, Latin, Political science or biology. It was reached by philosophy and chemistry and exceeded by economics, modern languages, mathematics, history and English. Plainly science in the colleges is not highly popular. It is interesting to note that chemistry, which appears as the most popular or the least unpopular of the sciences in college is also the only science which in the Commissioner's Report shows a slight gain in the high schools in the period 1910-1915, namely from 7.13% to 7.63%. Chemistry is likewise the subject which earliest responded to the demand for closer approximation to practical living.

Evidently science in the high schools has not been an unqualified success, if the interest shown by the students be a test. Close on the heels of this demonstrated fact comes the query,—What is the trouble? In a scientific age can not, must not the subject be made of vital interest and importance to the rising generation? How can it be done? This is the problem which the editor of the General Science Quarterly and his collaborators have clearly seen and are striving to solve. General Science, being a new departure and therefore comparatively unimpeded by tradition, offers an opportunity for the experimental solution of the question and experiments are being tried wherever it has been possible to introduce general science into the curriculum. This is perhaps an explanation and a compensation for the chaotic condition of expert opinion on the subject. I gather from my reading of articles that have appeared in this journal that whenever the experiment has been tried of presenting to the children problems such as arise in the course of their daily experience and of showing them how these problems may be solved by the application of "organized common sense" not necessarily subdivided into chemistry, physics or biology, that interest has been shown and curiosity aroused. Whatever criticisms have been leveled at this method have not been on the score of lack of an appeal to the real needs of the children. They have rather been that general science tends to be overcrowded and the material arranged without sufficient coherence. That the children's attention is held and their efforts stimulated is something very valuable gained. Coordination and rearrangement may be expected to follow with increasing experience and repeated experiments.

Heretofore this method of applying observation, experiment and reasoning to the affairs of everyday life has not extended beyond the 9th Grade. If, however, it has proved itself of value thus far and teachers are struggling with the overabundance of material thus secured, why not extend the same method to the remaining years of high school, why not continue to deal with daily experience as it is presented and not artificially confined within the boundaries of the special sciences? Are there essential advantages to be derived from studing chemistry as chemistry, biology as biology, etc. that would be foregone by such an extention and which would not be compensated for by the increased interest which the specialized sciences have not shown themselves able to maintain? The answer to this depends largely upon what it is believed desirable that high school boys and girls should get from their science study. The method of presenting the subject which has been in general use for the last twenty-five years has come down to the high school from the college and the college entrance examinations accurately guage what it is that the colleges require from the instruction of the high school. The following are questions taken from the groups of five, all of which must be answered and which are supposedly considered essential in the entrance examinations of 1916 in chemistry;—Define the terms "molecule", "atom", and "ion". State Avogadro's hypothesis, and show how it guides the chemist in determining molecular weights. Calculate the percentage of oxygen in crystallized copper nitrate.

College professors of science might be disposed to doubt whether the proposed method would give students sufficient familiarity with laws, definitions and calculations. On the other hand those directly engaged in teaching high school science and striving to fit the children for the responsibilities of actual life, which are likely to be unusually heavy in this century, will be inclined to inquire whether such familiarity can not profitably be postponed until college years while the high school devotes its energies to familiarizing the children with the real nature of life's daily experiences and the kind of observation and thinking which will enable them to understand and adapt themselves intelligently to its concrete situations.

Those who have taught students of high school age can not fail to have noticed that the minds of the majority are essentially

concrete. The often heard complaint "It was like pulling teeth to get that from the class" usually comes ofter a struggle for a definition of some abstract idea or proposition. The Greeks among high school students are few. They are chiefly Romans and Phoenicians and assimilate only the tangible and the useful. It may be said however, that chemistry as chemistry or physics as physics may be made tangible and useful and that there is no necessity for disturbing the traditional boundaries between the sciences. That special sciences can be so presented is without doubt true. Very excellent text books have appeared which demonstrate it. Nevertheless if we wish to bring home to the extremely concrete minded average high school student with the greatest possible emphasis the application of scientific principles to daily life, we must reproduce as nearly as practicable in school the actual conditions of real life where phenomena are rarely purely physical, chemical, etc. Every abstraction from the real lessons by so much the appeal and the vividness of the instruction.

If we cast aside then our inherited attitude towards the teaching of science and attempt without bias to discover the concrete experiences which are best adapted to give young people the sort of knowledge and training which will best fit them to appreciate the part that science plays in modern life, we shall be less likely to include in our courses information little used and therefore soon forgotten after graduation.

Two years ago I undertook, as head of the department of science in the South Philadelphia High School for Girls, to plan courses in science which would, as far as possible, meet the needs and interests of young girls. I gratefully acknowledge that the undertaking was begun under unusually favorable circumstances. The school was new and headed by an exceptionally liberal minded principal. The curriculum of the high schools in Philadelphia had not become rigidly standardized and, last but not least, I had the cordial cooperation of the other teachers in the department.

The first year of science is required of all classes and consequently must be adapted to a variety of pupils, i. e., those leaving school at the end of the first year as well as those taking commercial, home economics, academic and college preparatory courses. It seemed advisable, therefore, to give in the first year an introductory course which would furnish those who take no more science with some idea of the method and the fundamental inter-relations and applications of the sciences, while at the same time laying a foundation for more

advanced courses. It is pursued for five school periods a week and aims to give the children in the simplest possible way an insight into the real nature of such universal features of the environment as water, air, metals and mineral salts, how their properties make them of use to us in daily life, how living things in the form of green plants utilize them to make organic substances also useful to us, how other living things (fungi) break up organic material into simple substances again and cause decay, how animals depend on substances elaborated from the environment by plants for their existence and finally how certain forces as distinct from the material of the environment aid living things, man as well as animals and plants, in making use of the materials of the environment and in adapting themselves to it. I have found that this results in giving the children a familiarity with the commonest of the elements (carbon, oxygen, nitrogen, sulphur, phosphorus, etc.), the simplest of their compounds (carbon dioxide, oxide of iron, water, quick lime, etc.) and of the part they play in every day life (burning, breathing, boiling a kettle, rusting of iron, etc.) They appreciate also the part that plants play in making food for us and gain an elementary knowledge about their manner of life which can be practically applied in home and school gardening. The study of animals gives them a first hand acquaintance with the fundamentals of structure, physiology and reproduction which serves as a background for human hygiene. They also obtain an idea of what is meant by heat, light, electricity and sound and of the way these forces operate in such common occurrences as the ringing of a door bell, the boiling of water, the heating and lighting of a house.

The second year course I have called Household Science and have divided it into four main topics, i. e., Fuel, Building Materials, Food, and Clothing. To the development of these topics all of the sciences contribute. For example, biology aids in the understanding of the origin of peat and coal, of the properties and preparation of lumber, of the production and preservation of food and of the source and character of textile fibers, physics throws light on the proper management of a fire, the production of gas, the utilization of materials for the construction of buildings, tools and cooking utensils, while chemistry explains many of the processes used in the preparation and cooking of food and the manufacture of building materials and clothing. Necessarily there is constant reference to the information gained during the first year, not only a review of

the facts, but further applications of them and the addition of new but related knowledge. By the end of the second year, the formerly strange hydroxides, acids and salts with names and formulae difficult to remember have become more or less familiar acquaintances, bacteria and insects are seen more clearly to be both friend and foes and the practical value of heat and electricity are realized more completely.

Since the school is but two years old, the third year course has not yet been given. It is proposed that it should deal with the relations of science to undertakings which serve the needs of the community and may appropriately be called Civic Science. Such subjects as water supply and sewage disposal, sanitation, weather prediction, telephone and telegraph service, transportation, sources of power, printing, public recreation would come under this head. Again all of the sciences would be drawn upon in developing the topics and frequent incorporation of the work of previous years would be involved.

A discussion of the pollution of the water supply and its purification will necessitate a review of the previous work on the properties of soils, filtration, solution, hard and soft water, and the action of bacteria in decomposing organic matter and forming nitrates, while introducing as new material the simpler chemical tests for impurities and the geological formation of the Schuylkill and Delaware River water sheds. Closely connected with the subject of water supply will be the study of waste disposal and the value of sanitary plumbing. To understand this and the mechanics of the water supply, the students will need to become familiar with laws of physics pertaining to water and air.

In taking up the precautions practised by city authorities to prevent the spread of desease and to preserve human life, what knowledge of bacteria the students have already acquired will be further extended and correlated with the chemical nature and the action of disinfectants and antiseptics. Cultures of bacteria from various localities will serve to illustrate the danger of infection and the methods used to isolate different strains of bacteria. If time permits some of the more important devices used for diagnoses and disease prevention, such as x-rays, vaccination and serum injection will be included.

A review of evaporation, condensation, convection, etc., will make plain the use of weather instruments and the significance of weather

charts, while conditions favorable or unfavorable to plant life must be recalled in discussing the importance of weather prediction.

The subjects of transportation and sources of power, since they are in practice so inseparable, must be considered more or less closely in relation to each other. These as well as the study of the means of communication, ought considerably to enlarge the student's knowledge of physics and its most recent applications.

The same end would be served by a study of the acoustics and lighting of places of public amusement, of stereopticon, moving pictures machines, instruments of the orchestra and phonographs.

Not yet having given the third year course I am unable to say how much of this sort of ground can be covered, but, judging from the experience of the first two years, possibilities for subject development will be elastic and time limit rigid.

Altho the approach to the subject in the first three years is invariably through practical needs and interests, the theoretical side is not entirely neglected. Molecular and atomic theories, catalysis, hydrolysis, allotropy, the writing of formulae and equations, the distinction between force and work, the laws of work, the laws of conservation, of pressure in liquids and gases, the laws of reflection and refraction, the wave theory, the nature of noise and musical tone, and other more or less theoretical matters are touched upon in explaining phenomena. It is intended, however, in the fourth year to go more thoroughly into the nature of scientific theories and hypotheses, the intellectual necessities that gave rise to them and the effect they have had on the world's progress. Within the five periods a week allowed the ground covered would necessarily be limited, but it is hoped that it will be possible to give the class some idea of present theories concerning the constitution of the earth and its position in the solar system, of the gradual development of the conceptions which underlie these theories, of the men who devoted their lives to giving these conceptions a firm foundation and of the difficulties they met and overcame. This may be followed by an account of how we have arrived at an idea of the age of the earth and of the forces which have shaped it and of our gradual appreciation of the real nature of earth, air, water and fire. It is intended also to show how theories concerning living things have been developed and of the immense influence they have had on modern thought and action as well as to outline the theoretical basis of some of the most important inventions.

I have been moved to plan such a course as a climax to the high school science studies, not only because it will afford numerous opportunities to review and to bring into broader relations concrete facts and simple generalizations already assimilated, but also because of the need so often felt by workers in theoretical science of a wider knowledge by the public of the value of their labors, of their difficulty and of the time they consume. To prevent the course from becoming bookish and remote exercises will be required of the students, such as observations of the heavenly bodies, of the effects of wind, waves and weather, examinations of fossils and different kinds of rocks and as far as may be practicable experiments illustrating the more important laws or hypotheses.

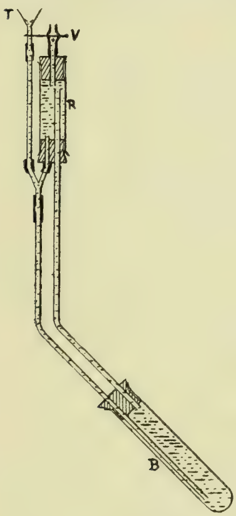
The four years course which I have described is taken by academic students, except college preparatory students. Commercial students are required to take the first year of science and, in the fourth year, one half year of commercial geography. They may also elect the second year of science if they so desire. Inasmuch as the subject of commercial geography is treated under the topics Fuel, Building Materials, Food and Clothing with regard to the factors which influence the areas of their production, distribution and sale, it is a distinct advantage to the commercial students to have had the foundation which the second year of science affords. For the hygiene required of all students in the last year, the work of the preceding years gives also a background, as by that time such subject as the nature of oxygen, carbon dioxide, osmosis, acids, bases, salts, carbohydrates, fats and protein, solution, emulsion, outlines of anatomy, physiology and reproduction, qualities of textile fibers, chemistry of cooking, etc. are familiar.

Altho the course is now only in the second year of its trial, I have as yet seen no reason to think that we have chosen the wrong path. I feel sure that the general science idea has virtues which are worthy of application beyond the ninth grade and that such an extension of its scope will go far to relieve the congestion and incoherence universally complained of at present. With more time in which to cover the field, the various topics will fall more easily into their natural relations. On the other hand, the greater precision of method and abstraction of ideas required by the specialized sciences as now taught and which have but little appeal to the average high school student will find their proper place in the college curriculum.

Hot Water System: Demonstration Apparatus.

By Percy E. Rowell, San Jose High School, California.

The drawing is almost self-explanatory. The boiler, B, is a 8x1-inch test tube, fitted with a two-hole rubber stopper. The radiator, R, is made from a similar test tube by holding the bottom of the tube in a flame until hot, and then blowing it out. If the hole so made is enlarged while hot, by means of an iron rod, it may be fitted with a one-hole rubber stopper. The overflow, or expansion tank, T, is made from a three-inch funnel. The "Y" connection is a glass "Y." The heavy lines indicate pieces of rubber tubing. The valve, V, is an ordinary pinch-cock. The long tubes are ¼-inch glass tubing.



Demonstration:

1. Filling the System—Add cold water to the tank. Water does not enter the system until valve is open. Why? Although the radiator is nearer the tank than is the boiler, the latter is filled first. Why? When the surface of the water reaches the top of the radiator, close the valve. The water should then stand at the same level in the tank pipe as in the radiator.

2. Heating the System—Apply the Bunsen flame to the lower part of the boiler. Although the long tube is nearer the bottom than is the short tube, the water becomes hot first in the short tube. Why? The hot water moves up the top tube. Why does it move? The water rises into the tank. Why? Is there more water in the hot system than in the cold system? Bubbles of air collect in the top of the radiator. Where do they come from? If the air is not permitted to escape through the valve the radiator will not become hot. Why? If the water boils the steam will escape through the tank. How would a system without a tank act?

3. Cooling the System—Watch and explain all that happens. What would happen if the tank was very small?

General Science Book Reviews.

Elementary General Science. By D. R. HODGDON. HINDS, HAYDEN & Eldredge. 575 pages. 395 Illustrations.

The science material treated in this text centers around the home. Two important considerations have been kept in mind in evolving this book; namely, that science information and the development of interest are both valuable assets. These two things are successfully met by the large volume of interesting material which has been assembled. The pupil finds the same incentive to look this book through as he does to read the popular science magazines but added to the interest which has been secured is a real science discussion which is too often lacking in the popular magazine.

Evaporation, moisture and the atmosphere are treated in a simple elementary way making special application to cooling processes and to weather. Chapters on heating and oxidation are followed by practical treatment of foods. This is followed by chapters on water, germs, and diseases. The first nine chapters have rather close relation to each other and are well organized. The last six chapters are less closely related and touch upon light, electricity, sound and music, the universe, machines and work, and "Safety First".

"Nostrums," "Safety First," and "Emergency Treatment," treated here, are subjects not found in other texts.

It will be seen that the book is physical science almost entirely and while it will find many teachers ready to welcome it on that ground, there will be some who will feel the lack of biological material.

Numerous illustrative experiments are given and stimulating thought questions are introduced at frequent intervals.

Course of Study in General Science. School Document No. VII, 1917, Boston Public Schools.

This pamphlet of forty-one pages was prepared by a council of eleven Boston teachers, representing the elementary, the high and normal schools. Work is provided for ninety forty-minute periods, in each of grades VII, VIII, and IX.

Gardening is suggested as an alternative for about one half of the time in grades VII and VIII for some schools. Type lessons are outlined.

The general plan of work is stated as follows:

Project

1. Problem stated and analyzed.
2. Materials and apparatus.
3. Directions.
4. Questions leading to
    (a) Observation
    (b) Results
5. Application to guide pupil's activities towards personal experience and home needs.
6. Notebook record.
7. Additional problems related to the original problem.

There are many helpful suggestions in the manual. The Council has made a substational contribution towards the solution of our ever present problems of general science.

Useful Pamphlets.

The folllowing list of pamphlets is submitted by Mr. A. H. Morrison of Boston Mechanics Arts High School:

Bulletin 1415 Fire Alarm Signal Co., Boston, Mass.
History of Light Welsbach Co., Phil., Pa.
Characteristics and Care of Storage Batteries
Ignition. Information Book (Ignition and Lighting)
National Carbon Co., Cleveland, O.

Ignition and Spark Plug Talks
Champion Spark Plug Co., Toledo, O.

How to Read Your Electric Meter
Gen. Elec. Co., Schenectady, N. Y.

Experimental Electric Testing by Students
Elementary Electric Testing, Monograph B2
Weston Electrical Instrument Co., Newark, N. J.

Farmers' Bulletins, U. S. Dept. of Agric., Washington, D. C.
Bulletins of the Bureau of Standards, Washington, D. C.
Witherbee Instruction Book
Witherbee Igniter Co., 541 W. 43d St., N. Y.

Books

Health in Home and Town, by Bertha M. Brown, D. C. Heath & Company, 312 pp.

This is a very valuable book. Not only does it furnish material on science related to good health of the pupils of Junior High age; but it is suggestive to teachers. Many of the chapter titles suggest a general science text as much as they do a hygiene text, for example, "How to Ventilate the House," "How to Warm the House", "How to Light the House", "Running Water in the House", "How to Care for the House", "City Food Supply", "City Water and Ice", "Diseases Dangerous to the Public Health."

Sanitation and Physiology. John W. Ritchie, World Book Company, Revised edition, 1917.

Part 1. Sanitation, 216 pages; Part 2. Human Physiology, 308 pages.

This gives an exceptionally complete course in hygiene, sanitation, and physiology.

In part 1 a summary of "Points to be Remembered" is found at the chapter ends. In part 2 each chapter is followed by a list of pertinent questions which give a thorough review of the chapter.

This book is adapted to pupils in higher elementary and lower high school grades, and is written in the style to interest them.

Science Articles in Current Periodicals.[1]

ACETYLENE

Acetylene Trench Gun, Ill. Pop. Sc. Mo. 92:586. April 1918.

AIRPLANE

The Technical History of the Airplane. Capt. F. M. Green. Sc. Am. Sup. (No. 2200) 85:130-131. Mar. 2, 1918.

AIRSHIPS

Baring the Super-Zeppelin's Secrets, Ill. Carl Dienstbach. Pop. Sc. Mo. 92:372-378. Mar. 1918.

ALCOHOL

Grain Alcohol from Garbage. Ill. World. 29:128. Mar. 1918.

ANTISEPTICS

Marvels in the latest Antiseptics. Cur. Opin. 64:336. May, 1918.

ARGENTINA

The Pampa of Argentina, Ill. W. S. Power. Geog. Rev. 5:293-315. Apr. 1918.

AVIATION

Aerial Torpedoes: Dropping Death from Skies. Ill. Carl Dienstbach. Pop. Sc. Mo. 92:518-520. Apr. 1918.

The Effect of High Flying. Sc. Am. Sup. (No. 2206) 85:227. Apr. 13, 1918.

Eyes in the Air. Ill. Henry Bruno. Pop. Sc. Mo. 92:508-511. Apr. 1918.

Mild Weather and the Air Man. Ill. Pop. Sc. Mo. 92:722-725. May, 1918.

Flying on Wings of Spruce. Ill. E. A. Sterling. Am. For. 24:133-139. Mar. 1918.

War Aviation. B. C. Hucks. Sc. Am. Sup. (No. 2209) 85:284-285. May 4, 1918.

BIRDS

The Humming Birds and Swifts. Ill. A. A. Allen. Am. For. 24:160-164. Mar. 1918.

The Kingfishes. Ill. A. A. Allen. Am. For. 24:91-94. Feb. 1918.

The Owls. Ill. A. A. Allen. Am. For. 24:219-224. Apr. 1918.

BOMBS

Dealing Death with Death Bombs. Ill. L. E. Darling. Pop. Sc. No. 92:562-567. Apr. 1918.

BURNS

The Treatment of Severe Burns with Ambrine. C. G. McMullin, M. D. (From Gen. Elec. Rev.) Sc. Am. Sup. (No. 2203) 85:190. Mar. 23, 1918.

CANAL

N. Y. State Barge Canal, Part II. Ill. Stanley W. Todd. Pop. Mech. 29:738-742. May 1918.

COAL

Artificial Anthracite. Lit. Dig. 56:9:23. Mar. 2, 1918

Our Annual Coal Drama. Ill. L. E. Darling. Pop. Sc. Mo. 92:530-536. Apr. 1918.

The Problem of the Coal Supply. Edw. W. Parker. Jo. Franklin Inst. 185:445-460. Apr. 1918.

How Much Heat is in Your Coal? Ill. C. Armstrong. Ill. World 29:34-35. Mar. 1918.

COLOR BLINDNESS

Color Blindness. (with diagrams). P. A. Maxwell. Gen. Sc. Quar. 2:410-414. Mar. 1918.

CONCRETE

Recent Progress in Concrete Construction. Ill. H. C. Campbell. Coml. Am. 14:9-10; 31-35. Mar.-Apr. 1918.

1 See Magazine List, p. 425, Gen. Sc. Qr. for March.

CRUTCH

A Crutch with Rockers. Ill. Lit. Dig. 56:15:24-25. Apr. 13, 1918.

DAYLIGHT SAVING

Hooverizing Daylight. Pop. Sc. Mo. 92:546-548. Apr. 1918.

DIVINING ROD

Divining Rod. A. J. Ellis. Sc. Am. Sup. (No. 2200) 85:138-139. Mar. 21, 1918.

DREDGING

Modern Suction Dredging. Ill. Chas. E. Fowler. Sc. Am. 118: 356. Apr. 20, 1918.

EGG TESTING

Testing Eggs by Photography. Ill. Jacques Boyer. Sc. Am. 118: 362. Apr. 20, 1918.

ELECTRICITY

Principles of the Electro Magnets. Peter J. M. Clute. Pop. Sc. Mo. 92:469-471. Mar. 1918.

Theory and Fundamental Principles of the Condensor. Ill. Peter J. M. Clute. Pop. Sc. Mo. 92:629-630. Apr. 1918.

* Principles of the Induction Coil and Transformer. Peter J. M. Clute. Pop. Sc. Mo. 92:793-795. May 1918.

Economic Industrial Applications of Electricity. N. T. Wilcox. Sc. Am. Sup. (No. 2201) 85:146-147. Mar. 1918.

Electro-Static Experiments. F. Von Lichtenow. El. Exp. 5:768. Mar. 1918.

ENGINES

Propulsion of Ships. Eskilberg. Jo. Franklin Inst. 185:317-332. Mar. 1918.

EQUILIBRIUM

How the Concrete Ship Turns Over. Ill. Lit. Dig. 56:5:18. Feb. 2, 1918.

EXPLORERS

American Explorers of Africa. E. F. Balche. Geog. Rev. 5:274-281. Apr. 1918.

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Accomodation and Chromatism of the Eye. The Optical Jo. and Rev. of Optometry. 41:2:94. Jan. 3. 1918.

FARM MACHINERY

Mechanical Equipment of the Farm. Ill. B. P. Potter. Sc. Am. 118:193. March 2, 1918.

FISH

A Method of Fish Study for Beginners. G. C. Embody.
The Physiognomy of Fishes. R. W. Shufeldt,
The Salmon. J. R. Traver.
Nat. St. Rev. 14:4 (Fish number) Apr. 19, 1918.

FOODS

Foods for Fighters Lit. Dig. 56:8:22 Feb. 23, 1918.

Food for All. A Fundamental War Problem. Ill. Sc. Am. 118: 310. Apr. 6, 1918.

The Palate of Civilized Man and Its Influence on Agriculture. David Fairchild. Jo. Franklin Inst. 185:299-316. Mar. 1918.

Drying Vegetables and New Conservation Move. Ill. Arthur L. Dahl, Sc. Am. Sup. (No. 2200) 85:134-135. Mar. 2, 1918.

Milk and Cheese Compared with Other Foods. Ill. World 29: 428 May 1918.

Food Values. Lit. Dig. 56:9:28. Mar. 2, 1918.

The Soya Bean. Ill. Hudson Maxim. Pop. Sc. Mo. 92:686-688. May 1918.

Our War Sugar Bowl. J. W. Herrington. Pop. Sc. Mo. 92:710-711 May, 1918.

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Peanuts as Food. Lit. Dig. 86:15:22 April 13, 1918.

The Peanut's Bit. J. D. Stuart. Country Life. 33:660. Apr. 1918.

Peanuts for Oil Production. Agri. Dig. 2:930. Apr. 1918.

Modern Margarine Technology. W. Clayton. Sc. Am. Sup. (No. 2200) 85:134-135, Mar. 2, 1918.

Saccharine as a Sugar Substitute. Sc. Am. Sup. (No. 2206) Apr. 13, 1918.

Some Essentials to a Safe Diet. E. V. McColllum. Jo. Home Econ. 10:57-63. Feb. 1918.

Why Send Wheat? Lit. Dig. 57:3:29. Apr. 20, 1918.

The Whale as a Food Factor. C. H. Claudy. Sc. Am. 118:208-9. Mar. 9, 1918.

Food Exhibits and Lessons. Gen. Sci. Quar. 2:399-406. Mar. 1918.

Fire and Efficiency

Reducing Fire Hazard (for motorists) T. W. Benson. Ev. Eng. Mag. 4:264. Mar. 1918.

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Effective Methods of Fly Control. Thomas J. Hedley. Sc. Am. Sup. (No. 2201) 85:150-151. Mar. 9, 1918.

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Flowers that Fertilize themselves. A. A. Hansen. Sc. Am. 118: 406. May 4, 1918.

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Woodland Development. Hans J. Koehler. Country Life. 33:6: 50-51. Apr. 1918.

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Flowers for the War-time Garden. Ill. Elizabeth Strang. Garden Mag. 27:37-130. Apr. 1918.

When to Plant in any part of the Country. Garden Mag. 27:136. Apr. 1918.

Managing a One-Half Acre War Garden. Ill. F. G. Paris. Garden Mag. 27:131-134. Apr. 1918.

Preparedness in the Vegetable Garden. Agri. Dig. 2:825-826. Feb. 1918.

Making a Nation of Garden Cities. Ill. C. L. Pack. Garden Mag. 27:183-186. May, 1918.

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Methods of Gas Warfare. S. J. M. Auld. Jo. Ind. & Eng. Chem. 10:297-301. Apr. 1918. Sc. Am. Sup. (No. 2200) 85:142-144. Mar. 2, 1918.

The Gas Attack and Liquid Fire in Modern Warfare. (From Am. Medicine) Sc. Am. Sup. (No. 2203) 85:189 Mar. 23, 1918.

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What Happens Inside the Cylinder of Gasoline Engines, G. Reinberg, Jr. Ev. Eng. Mag. 4:275-276. Mar 1918.

Keeping the Engine in Prime Condition. Ill. V. W. Page. Ev. Eng. Mag. 4:277-279. Mar. 1918.

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Browning, the Gun Wizard. Ill. E. C. Crossman. Pop. Sc. Mo. 92:538-541. April 1918.

The Browning Guns. Sc. Am. 118:206. Mar. 9, 1918.

The Lewis Automatic Machine Gun. Reginald Trantschold. Ev. Eng. Mag. 5:67-68. May, 1918.

The Lombard Gun: the Mechanical David. Pop. Sc. Mo. 92:699. May, 1918.

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The German Long-Range Gun. Sc. Am. 118:309. Apr, 6, 1918.

Electric Trench Gun. Ill. Pop. Mech. 29:641. Mar. 1918.

Long-Distance Guns Shell Paris. Pop. Mech. 29:656. May, 1918.

Velocity and Range of Guns. Ill. J. Bernard Walker. Sc. Am. 118:360-361 and 381. Apr. 20 and Apr. 27, 1918.

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Shall Forestry be Taught in the Public Schools? Ill. J. W. Toumey. Am. For. 24:103-108.

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Six Months of Home Grown Berries. M. G. Kains. Country Life. 33:6:65-67. Apr. 1918.

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Hot Beds in Which Safely to Start Early Plants. Ill. Pop. Sc. Mo. 92: 447-448. Mar. 1918.

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Modern Iceland. Ill. Godmundur Kamban. Geog. Rev. 5:195-207. Mar. 1918.

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The War on Insects. F. L. Bouvier. Sc. Am. Sup. (No. 2209). 85: 274-275. May 4, 1918.

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Light Projection. C. A. Halvorson, Jr. and R. B. Hussey. (Originally in Trans. Ill. Eng. Soc.). Sc. Am. Sup. (No. 2207). 85; 254-255. Apr. 20, 1918.

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Lighting Curtailment. Preston S. Millar. Trans. Ill. Eng. Soc. 13: 111-169. Mar. 1918.

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Human Aids to Machines. A. R. Bond. Sc. Am. Sup. (No. 2209). 85: 278-279. May 4, 1918.

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War Meat and War Animals. Agri. Dig. 2: 877-878. Mar. 1918.

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Indian Medicines made from Trees. Ill. H. Maxwell. Am. For. 24: 205-211. Apr. 1918.

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Mice Ruin Wheat at Australian Depot. Pop. Mech. 29: 401-404. Mar. 1918.

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Making Models as a Profession. Jack M. Roy. Ev. Eng. Mag. 5: 55-57. May 1918.

Modeling from Nature: Wax. Ill. Percy Collins. Sc. Am. Sup. (No. 2207). 85: 248-250. Apr. 20, 1918.

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Migration as a Factor in Control. T. J. Hedlee. Sc. Am. Sup. (No. 2205). 85: 214. Apr. 6, 1918.

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A New Cycle in Motion Picture Projection. Ill. Sc. Am. 118: 259. Mar. 1918.

MOTOR-CARS

Gas-Driven Motor-Cars. Ill. Lit. Dig. 56: 8: 18. Feb. 23, 1918.

OYSTERS

Oysters: The Food That Has Not "Gone Up." Ill. H. F. Moore. Sc. Am. Sup. (No. 2203). 85:184-187. Mar. 23, 1918.

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How to Do Oxy-Acetylene Welding. Ill. J. F. Springer. Ev. Eng. Mag. 4:265-267. Mar. 1918.

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"Perhaps Our Greatest National Park." Ill. R. S. Yard. Am. For. 24:145-150. Mar. 1918.

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The Development of the Philippine Islands. Ill. J. J. Walters. Geog. Rev. 5:282-292. Apr. 1918.

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Blue and Brown Print Paper: Characteristics, Tests, and Specifications. Veitch, Sammett & Reed. Jo. Ind. and Eng. Chem. 10:222-226. Mar. 1918.

The Dufay Versicolor Process in Color Photography. Ill. Sc. Am. Sup. (No. 2206) 85:237. Apr. 1918.

Photographs Enlarged With Any Folding Camera. Ill. Roy Lamont. Pop. Mech. 29:783-784. May, 1918.

Photography, Including Colored Photography. Ill. J. J. Furia. El. Exp. 5:760. Mar. 1918.

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Pruning for Fruit This Year. M. G. Kains. Garden Mag. 27:78-79. Mar. 1918.

PTOMAINE POISONING

The Persistent Delusion of Ptomaine Poisoning. Cur. Opin. 64:262. Apr. 1918.

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The Project in Home Economics Teaching: Definition of a Project. W. W. Charters. Jo. Home Econ. 10:114-119. Mar. 1918.

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Cleaning the Streets of a City. Ill. M. E. Thompson. Com. Am. 14:27-33, Feb. 1918.

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A Small Sewage Disposal Plant, Ill. Pop. Sc. Mo. 92:461-465. Mar. 1918.

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Causation of Sex in Human Race. Cur. Opin. 64:263. Apr. 1918.

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Ferro-Concrete Ships. Sc. Am. Sup. (No. 2209). 85:286-287. May 4, 1918.

Ships to Smash the "Sub" Blockade, Ill. David Wells. Ill. World. 29:251-256. Apr. 1918.

Unsinkable Ships. Charles V. A. Eley. Sc. Am. Sup. (Nos. 2206 and 2207) 85:238-239 and 250-251. April 13 and 20, 1918.

World's Largest Concrete Ships, Ill. Pop. Mech. 29:644-646. May, 1918.

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Eliminating the Smoke Nuisance By Electricity. (Cottrell Process) W. H. Easton. El. Exp. 5:749. Mar. 1918.

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Flying on Wings of Spruce. Ill. E. A. Sterling. Am. For. 24: 133-139. Mar. 1918.

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The Care of the Storage Battery, Ill. Ev. Eng. Mag. 4:270-272. Mar. 1918.

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American Source of Supply for the Various Sugars. C. S. Hudson. Jo. Ind. & Eng. Chem. 10:176-178. Mar. 1918.

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